From Ambivalence to Excitement and Concern

A Longitudinal Study of the Perceived Future of Robotics

An Interactive Qualifying Project Report

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ABSTRACT

This study is an extension of a previous longitudinal study conducted at Worcester Polytechnic Institute on shifting student perceptions regarding the future of robotics. Participants were enrolled in a Science, Technology, and Society class focused on the social implications of robotic advancement. The opinions of the participants were collected by means of a questionnaire that assessed the perceived likelihood and desirability of four fictional scenarios of potential robotic futures in terms of likelihood and desirability.

The major difference between this study and a prior one was the replacement of an aquaculture-themed scenario with a domestic police drone scenario. Another difference was the quality of the data set, as there was substantial missing questionnaire data in the data set prior previous study. As a result the final round of data collect involved coding essays that could not be rigorously linked to the prior questionnaire data. In this study there were 3 rounds of questionnaire data collection with high response rates.

I found that the students altered their opinions as they learned more about the subject and discussed it with peers. The RBE majors often reached different conclusions about the desirability of a scenario than students with other technical majors. The pattern was to become enthusiastic about the possibilities after reading a book on the subject and then tempering that enthusiasm after discussion with peers. By the end a consensus was emerging.

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SECTION 1: INTRODUCTION

Introduction: *adapted from* Conwell, Sharood, and Vander Els, 2012

This study focuses on understanding perceptions of the future of robotics among aspiring technologists. What makes it special is that it is a longitudinal study that traces the effects of becoming more informed about the policy debates surrounding robotics on these perceptions. I was also to connect this to opinions about appropriate regulatory policies. The context of the study was a class of about thirty students taking a Science, Technology and Society class on emergent technology taught by a sociologist. It was called "the Society-Technology Debate" and focused on the issue of whether and how technology can get out of control. An adapted version of an existing "perceived futures of robotics" questionnaire was used to ascertain initial uninformed opinion. These data were comparable to that gathered in two prior studies in that variants on the same questionnaire were used. The first study was comparative rather than longitudinal. The questionnaire was not re-administered but rather administered to liberal arts majors at two other colleges as well as technical students, half of which were majors in robotics or computer science, at two other universities. The second study was an effort to be longitudinal but was methodologically flaw in ways that led the questionnaire data to dwindle to the point that the data collection procedures changed between T2 and T3, compromising the comparability of the last wave with the prior two. In this study the questionnaire was successfully re-administered two more times, with T2 and T3 capturing moments of significant increases in knowledge in the process of perception formation.

I was also a participant observer in one of the key activities that preceded the last round of data gathering. I helped to develop a mock Congressional Committee hearing and did most of the work with those role-playing the members of the House Science, Space and Technology committee. The mandate of this committee does not extend to what the DOD (Department of Defense) is doing, but it covers the civilian side of most science and technology issues quite well. Both the House and Senate Science committees have specific responsibilities overseeing the space program and private sector activities in the field of robotics. One of the scenarios involves a private initiative to mine the moon for energy resources using mostly semi-autonomous robots. Such a venture would be specifically under the purview of this joint committee.

I had to brief myself as much as the students in the class did to understand our government's science and technology policy making process, which raises a lot of questions if you think about it. Professor Wilkes and I both read, and I analyzed a set of papers from the students written at the end of the class in which they reflected on the process and noted which things they felt influenced their views the most. This debrief added to the questionnaire data gave us an adequate longitudinal dataset to look at how the participants' perceptions and opinions changed over a period of about two months.

As technological capabilities in this field have improved exponentially, we have become better able to produce robots that can be either beneficial to society or become the means to rip it

apart. The use of drones in warfare has become a primary mode of operational control and the effects of these drone strikes are all too close to home.

In general the objective of the study was to examine what the next generation thinks of the problems we are facing today and ones we could possibly face in the future. The results of this study will shed light on how future opinions and policies on robotics might shape emergent robotic technology. This study's main focus was the effect of relevant learning and peer discussion on change in perception and opinion. While the answer would seem to be that this is likely, there is substantial body of social theory about selective perception that suggests one tends to retain the information that is consistent with one's views, and tends to miss or forget the discrepant information. Thus, learning more and having to defend one's position against critics does not necessarily lead to a change of opinion.

Between 2008 and 2012, there were 147 documented drone strikes, with a total of 894 persons killed and an additional 211 people injured. The ethics debate about the social implications of our increasingly robotic society was drawn to the center of public attention by the debate about semi autonomous killer machines and the emerging man-machine relationship that represented. Public opinion around the world was very negative though a solid majority of the American public supported the use of Predators as a way to reduce military casualties.

Robotics has entered every portion of our lives from farming, to manufacturing, and cleaning, and it has been particularly important in the theater of war. It is no secret that the direction of technology is affected by its funding. Funding from the defense sector going to the field of robotics from entities like the Defense Advanced Research Projects Agency (DARPA) has given a characteristic direction to the research and development of robotics.

I sought to understand the current generation's perception of the direction of robotics and their opinions on the best course going forward. I assessed the perceived future of robotics, from the uses seen in the military to private sector applications. Additional assessments were made of the effect of this course on the ethical understanding and maturity of thought the students developed during the process of information acquisition and debate.

I will also suggest points of interest for future research, and the course that most of the participants decide is best is of interest since if there is a consensus about that in technical community it should be influential the setting policy direction that professional societies would endorse and enforce. I personally am also interested in seeing whether this type of educational experience is capable of making it substantially more likely that students graduating from WPI have a sober and balanced understanding of the implications of creating technology in many field but especially robotic weapons and the ethics involved in their proper deployment and use. As they become more and more autonomous the issues the next generation will face in this field will become more and more problematic. I hope they are up to meeting this challenge without letting unconstrained technological enthusiasm go so far as to provoke conflict with professionals in other fields such as Law and Medicine as well as the general public.

In the media we see a polarizing debate facing the development and expansion of weapons research. The United States military budget is more than double that of the rest of the world combined and many people question the need for such extravagant spending and question its sustainability. The Research and Development (R&D) budget in 2011 for the US Department of Defense (DOD) was $79.1 billion. This included $1.9 billion for continued development of the 'Predator' and 'Reaper' Unmanned Aerial Systems (UAVs), the go-to system for tactical strikes, and the same equipment used for the previously mentioned drone strikes. There are those in our government who would increase this budget every year, and there are those who believe that we need to lower military spending in favor of other activities and different robotic applications.

With such massive developments being made in the field and such huge fiscal commitments to continued military development it is prudent to consider at least the most likely results of our actions. Has the US generally, and the Department of Defense in particular, eagerly rushed headlong into a new era without considering the consequences of our decisions? This study was created to look at where people think we are and where they think we are going, especially those currently studying in the field of robotics.

In order to encourage the students to really consider multiple facets of this problem we integrated this study into a social science class on technology and society. In this class students were assigned relevant contemporary reading and participated in a mock congressional hearing designed to spark debate and encourage critical consideration of our current policies. In this endeavor, we found we were largely successful in that students who answered both the initial survey before the class and the final survey at the end of the class had changed or strengthened but rarely just maintained their initial opinions. Additionally, the students submitted a paper reflecting on the process where we found many of them described considering problems they had not thought of or viewpoints they were unfamiliar with and they often noted that this affected their final opinions.

One of the issues we ran into with this study was the fact that this is an ongoing controversy. Even the book Wired for War, which is only a few years old, feels dated at times and it is hard to keep a consistent bead on the actual level of technology available to the DOD versus the known projects and perceived technology level. Still, with these problems being considered right now, it is the best time to encourage the development of informed opinion to ground the oncoming policy debates. In this study we start with technically literate participants and inform them about a policy issues while grounding them in relevant information. The book they read served as a briefing paper. Then one finds out what the students about to enter the field of robotics think is likely for the future- at least the part of it may span their careers. These perceptions are then compared to those of a technically literate but not "expert" sample. My unique position as a teaching assistant allowed me to observe, inform and to people who will be entering this debate in the real world in the next few years. This sort of closeness to the source is almost unprecedented in the field of social research and makes this class invaluable to the students working in robotics and to the WPI community as a whole.

Hypothesis

A hypothesis of this study, as well as that of the Fear the Robots study conducted by Conwell, Sharood, and Vander Els in 2012, was that students would change their opinions on the various scenarios first after reading Wired for War along with other assigned literature and again after participating in the mock Congress committee debate activity.

According to the theory of Selective Perception, the students would mentally filter out facts by ignoring or forgetting them if they were dissonant (contrary) to their preexisting opinions. If so, the information that they would receive over the course of the class would not change their opinions. In this way, any useful information would only be used to improve their articulation when arguing their viewpoint. A longitudinal study would enable to us to determine this theory's validity in this situation.

Another hypothesis was that the least desirable scenario was also the most likely. This was not a matter of principle but rather a prior finding that we thought would replicate. The Fear the Robots team and the Brauckmann team had found this to hold true with the Military scenario. However, their studies included the Water World scenario. The Police Drone scenario would put this expectation to the test. Logically space and military were still the extreme cases on ethical grounds. However, the drone was likely to be rated as more likely and less desirable than the one it was replacing. The question was how it would be perceived relative to the military applications of the same basic technology.

Response Rate

The primary motivation for this study was the poor response rate that plagued the findings of Fear the Robots IQP team, which got less than a 50% response rate to their T2 survey administration. Given the small sample, this made them reluctant to draw conclusions and rendered that study largely inconclusive on one of their major questions. They did not do a third-round survey on the grounds that it would have been pointless, so they tried to interpret essay question results to get T3 data and could not demonstrate that they were measuring the same variables reliably. This team had administered the T1 questionnaire in-class and left the T2 to be completed at home and returned later. Although they had begun with 28 participants, only 12 returned the second questionnaire, a response rate of 42%. Hindsight reveals that this was a mistake. Hence, I argued for in-class administration of all three surveys if it was worth doing the study at all. I won that argument with the professor hosting the study in his class. In this study, all questionnaires were administered in class rather than as take-home assignments. In this manner, I would only lose those students who dropped the class, were absent on the day, those who miscoded their symbol or those refusing to participate. Willingness to participate was not a problem, so this procedure resulted in a response rate of 82% (28 out of 34) of initial participants, a far more acceptable number for statistical purposes. Further, this included those only those who answered all three questionnaires. The attrition from T1 to T2 was smaller,

mostly those three students who dropped the class. The two who joined the class late were not full participants in this study. Students who participated were also given extra class participation credit for each returned questionnaire as a minor incentive.

SECTION 2: LITERATURE REVIEW

Literature Review: *adapted from Fear the Robots*

Wired for War, by P.W. Singer, is the first of several readings the students in the class completed. Wired for War was published in 2009 and quickly became a bestseller. When the book first came out, it helped bring the conversation of the implications of robotic technology to the public eye. In the book, Singer raises an argument that urges the reader to think about possible consequences of modern robotics technology.

The book is separated into two parts. In the first part, Singer presents the reader with copious facts and statistics about the developing robotics industry. The statistics shed light on the pace of development in the robotics industry and the flow of research funding. However, the examples Singer focuses on are robots developed for and funded by the military. The majority of the statistics are related to military applications and development and are less focused on the development of robots for commercial markets. He compares the funding of these two markets but does not directly examine commercial robots, as the title implies.

In part one, Singer also introduced the reader to the idea of the 'closed loop', or a robot that can make decisions without human approval. The discussion in the book is centered on robots in control of weapons. This reflects the current generation of applications in which humans still pull the trigger on weapons carried by drones. The questions is whether the goal should be to produce autonomous artificially intelligent robots that are able to make decisions about when to engage and therefore capable of weighing human life with legal and moral implications. In short, this is a debate about who is accountable for such actions.

In the beginning of part two Singer discusses radical paradigm shifts that rewrite the rules of war, which he refers to as 'Revolutions in Military Affairs' (RMAs). He proposes that the development of robotics will have far reaching effects on society. Singer likens the possible changes in society due to the development of robotics to the changes in society that came about with the advent of the automobile. The second part of his book centers on possible negative consequences of robotic technologies.

Literature Review and Research Strategy: *adapted from Michael Brauckmann*

A robot is a machine built upon the "sense-think-act" paradigm. That is, they are man-made devices that sense their environment, process data, and respond based on what they've perceived (Singer, 67). The PackBots, which have been deployed in Afghanistan and Iraq, are far from the only robots out there. iRobot also makes the Roomba, small disk-shaped vacuum cleaner robot. Predator drones armed with missiles patrol foreign skies. Industrial robots

tirelessly work on the production lines of factories across the globe. The field of robotics is developing extremely quickly.

In Wired for War, P.W. Singer tells the story of this emerging technology and its impact on society. The vast majority of research in this field in the United States comes from military funding programs such DARPA. According to Singer (2010), some eighty percent of what is spent in this country goes to the DOD. Programs for developing a single robot frequently have budgets in excess of several million dollars. The first section of the book covers the current robotic technologies employed by US troops in Iraq and Afghanistan. From clearing improvised explosives and roadside bombs, to flying surveillance missions in Iraq, to taking out insurgents with Hellfire missiles, these early robotic warriors have paved the way for robotics in the military. Some of these robots are designed as scouts, made to go into places people don't want to. Others, such as Foster-Miller's SWORDS platform and the predator drone, are intended to hunt down and kill humans.

While the original PackBot and Talon bomb-disposal platforms included robotic arms, Foster-Miller's SWORDS version of the Talon is a prototype designed to carry and fire weapons. Capable of carrying anything from an M16 to a fifty-caliber machine gun to a rocket launcher, the SWORDS robots are amazingly accurate in their targeting (Singer 30). iRobot is similarly developing a shotgun-wielding version of their PackBot. Singer interviews the scientists and engineers developing these robots, as well as the soldiers who use them. Through these interviews, the argument is made that these technologies are the building blocks to a much greater change in the way we fight wars. The possible developments that come from combining these technologies with others like communication networks and artificial intelligence could easily be scenes from a movie, and indeed many of these concepts draw their inspiration from science fiction.

In 1998, Vice Admiral Arthur Cebrowski predicted that the introduction of computers and near-instant communication would produce something he termed "Network Centric Warfare." He predicted that this change would be a Revolution in Military Affairs. "RMAs typically involve the introduction of a new technology or organization, which in turn creates a whole new model of fighting and winning wars. A new weapon is introduced that makes obsolete all the previous best weapons (Singer 2004)." Just as the introduction of guns made highly trained knights nearly worthless, Cebrowski predicted that near-instant communication would create a similar change in warfare. Unfortunately, network-centric warfare introduced a sort of information overload, proving Cebrowski wrong. Singer predicts that robotics will be the technology that actually revolutionizes military affairs, "perhaps even leading to the rise and fall of global powers (Singer 2004)." This is especially likely to be the case if it is combined with the new communications infrastructure that massively increases the situational awareness of soldiers in the field and their commanders far from the front lines.

However, Singer looks beyond the RMA. He sees robotics causing a cascade of interdependent and complicated changes within society in general. The social implications of these technologies and the changes they bring about are far-reaching, and unforeseen effects may

be even greater than the predicted outcomes. Singer cites Futurist Ray Kurzweil, whose company focuses on predicting trends in technology to "catch the train at the right moment." Kurzweil believes that we are on the verge of such technological breakthroughs that they will change all the rules in an event he calls the "Singularity" (Singer 2004). Singer and Kurzweil are not alone in their belief that robotics is bringing about the singularity which will turn the system we know upside down. Bill Joy is the cofounder of Sun Microsystems and author of a short article entitled "Why the Future Does Not Need Us", in which he explains why he is uneasy about the danger we face in the twenty-first century (Joy). Joy's anxiety started when he read a preprint of Kurzweil's book, The Age of Spiritual Machines, a story of a utopian future where man becomes one with robotics and gains near-immortality. But Joy did not see this as a likely path of the technology Kurzweil described; instead, he saw a future in which mankind has made itself all but obsolete. Joy urges us to consider the consequence of allowing more and more decisions to be made for us by machines. He warns that no hostile takeover or willing surrendering of control will be needed. The technical system will simply become more and more complex until no human will be able to make intelligent decisions and we will become so dependent on the machines that flipping the power switch would be tantamount to suicide (Joy). Joy compares robotics along with genetic engineering and nanotechnology to Pandora's Box and warns that we have nearly opened it, and what comes out will never be put back in a box. In his words: "we are being propelled into this new century with no plan, no control, and no brakes. Have we already gone too far down the path to alter course? I don't believe so, but we aren't trying yet, and the last chance to assert control - the fail-safe point - is rapidly approaching" (Joy).

Another author, Kevin Kelly, writes in his book What Technology Wants that something entirely new has emerged which he calls the "Technium". He finds technology analogues to a biological organism evolving as much by internal processes as by human choice. He claims it is "whispering to itself", becoming increasingly autonomous and has urges and a direction in which it wants to go. Kelly claims this technium has become "as great a force in our world as nature" and it would be unreasonable to expect it to obey us. Rather than even attempt to control it, he guides us to learn what it wants, and where it will go, to listen to it, and decide how to "optimize technologies blessings while minimizing the costs". The increasing trend toward autonomy is evident in his work and commented upon extensively. Von Neumann, the inventor of the first useful computer, whose architecture is still prominent in many microprocessors, noted that technology was a process of increasing "structure, organization information, and control." Kelly called it "a vital force that throws us forward or pushes against us."

This study was inspired by Singer's book Wired for War and his concerns and warning about the current trends in the field of robotics. One of the four scenarios is drawn loosely from his description of our projected ahead. When confronted with ideas like those expressed by Joy and Kelly, Singer's warning may even come across as a moderate voice. The shape of the future lies in the balance of the policies, social changes, and decisions made in the present. We can consider the lessons of the regretful scientists who worked towards the development of the atomic bomb.

"The danger is that things will move to fast, and in a way in which the process can take on a life of its own. We can as they did create insurmountable problems in no time flat. We must do more thinking up front if we are not to by similarly surprised and shocked by the consequences of our inventions." (Singer 2004)

Even Bill Joy, in his pessimistic view of the future and near certainty that we were creating a dystopian future, believed that this was the moment to take a stand.

"Have we already gone too far down the path to alter course? I don't believe so, but we aren't trying yet, and the last chance to assert control - the fail-safe point - is rapidly approaching… If we could agree, as a species, what we wanted, where we were headed, and why, then we would make our future much less dangerous - then we might understand what we can and should relinquish. I believe that we all wish our course could be determined by our collective values, ethics, and morals. If we had gained more collective wisdom over the past few thousand years, then a dialogue to this end would be more practical, and the incredible powers we are about to unleash would not be nearly so troubling." (Joy 9)

It may not be possible to predict the course of technology and, even if it is possible, controlling what that direction might still prove to be an insurmountable problem. However, if no attempt is made then we are certainly left to the whims and urges of Kelly's technium, whatever they may be. It is the author's opinion that it would be foolish not to make every effort to understand and direct the path of these technologies. If we make it our goal to understand where this technology is taking us and to shape our socio-technical policies so as to guide it in a favorable direction, then that at least improves the odds that the future will be the result of our deliberations rather than technological inertia. Wired for War gives the reader an idea of the changes to come and raises many important questions about robotics and human nature itself that must be answered. Surely then, it is a good idea to take a look at what futures are possible and ask how people perceive them.

To this end, we developed our four scenarios, each outlining a different possible future for the field of robotics. Each scenario varies in that the institution driving technology has different goals and ambitions which lead to a different path of development. Hence, responses will reveal the perceived effect of the institutional goals and mindset. Singer seems concerned that the US military has ill-advisedly crossed an ethical line in the man-machine relationship, and will one day regret having done so after the USA is no longer the technological leader in the robotic field. It is only a matter of time before the USA's current military capabilities are widely available to other nations and hostile political groups. According to Singer, it is possible to be short-sighted and act in this way because the military avoids looking at the ethical implications of the technologies they work with. As Michael Goldblatt, DARPA's defense sciences office director, put it: "you can't let the fear of the future inhibit exploring the future." In the words of another DARPA program manager: "[considering ethics] is above my pay grade." Hence, we thought to incorporate an ethical dimension into our scenarios.

The iRobot corporation takes its name from Isaac Asimov's book I, Robot. Considering that iRobot is developing killer robots, this association is rather peculiar. Asimov was a science

fiction writer and published a series of short stories known as I, Robot during the late 1940's. The book describes how, over the course of a lifetime, robotics begin as simple mechanics and develop into complex entities containing "positronic brains" somewhat more like the human brain than microcontrollers. In this alternate future, all robots follow the Laws of Robotics:

•A robot may not injure a human being, or through inaction, allow a human being to come to harm.

•A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.

•A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

With these ethical laws in place, humanity thrives in the company of these intelligent machines. Dr. Susan Calvin, a robo-psychologist, explains that strict adherence to these laws prevents robots from performing act or undertaking tasks that are immoral, dangerous, or generally undesirable.

iRobot's machines clearly violate all three of Asimov's laws. The military, in fact, "explicitly wants robots that can kill, won't take orders from just any human, and don't care about their own lives. "So much for Laws One, Two, and Three (Singer 432.)" The people at iRobot, however, believe that Asimov would "think it's cool as hell (Singer 25)." In our scenarios, each institution driving the development of robotics takes a different stance on robotic ethics. We chose to adopt Asimov's three laws as our basis of ethics. Thus every institution varies in its ability to accept Asimov's laws given its goals. By gathering people's perceptions of these scenarios, we hope to see if acceptance of Asimov's three laws reduces concern about ethical issues and stand as a guide for ethics in the field of robotics.

The design of this study is inspired by the Delphi study technique which traditionally includes a panel of experts in the field being assessed. Our study differs from this format in two basic ways and there are precedents in the Technology Assessment and Public Understanding literatures. We have chosen to use a student sample instead of experts and we chose to sample from aspiring 'experts' both in and outside the field of robotics. It is the robotics majors who will stand in for our panel of experts. Previous research on public perceptions of nuclear technology showed that the views of students could approximate the literate college educated portion of the US population called the attentive public. Another study in aerospace innovation (Climis et al.) showed that student opinions were a rough approximation for expert opinions. This study included WPI students, WPI graduates, and experts and found that for the technological breakthrough that 80% of experts found most likely, about half of the students also found most likely. The other 50% of student tended to be a random scattering of other responses strengthening the overall patter of agreement with the experts. Hence, the more attainable student sample is preferred. Moreover, the scenarios are set in the timeline of the careers of current students so the technological developments discussed represent the contribution of the next generation to the field this makes current students a more appealing sample than current experts.

As for the students outside the field of robotics (which includes other technical majors and non-technical majors), research on the telephone suggests that those affected by a technology may provide more accurate predictions than the engineers involved in the development of the technology. Similarly, there will clearly be other voices, in the public debate over robotics and involved the process of making polices, which are not those of technical experts in the field.

Ellul describes a "Technological Mentality" which is employed by engineers and scientists. It is largely based on efficiency criteria and involves a narrowly focused preference for objective criteria and short term implications. While this mentality has certainly aided in the development of increasingly useful and efficient technologies, it results in short term thinking and can lead people to miss side effects with unintended consequences.

The non-technological members of society tend to think more long term, and more easily consider the effect of a technology outside of the domain of application it was designed for. These predictions are based on hunches, experiences, and judgments about what new capabilities the technology might provide. This subjective thinking is rarely convincing to the efficiency oriented expert engineers. None the less these predictions often prove accurate once a technology is developed and its unintended effects begin to trickle into society. For example, when the telephone and telecommunication equipment first became available most of the engineers working on it pictured a mass media communications system like today's radio broadcasts. They claimed there would be phone lines fanning out from the opera halls so all the world could listen in. Obviously this was not the most substantial effect of the new technology, which was more suitable for point to point communication than broadcasts. However, at the time, radio was being used for ship to shore communications and other point to point applications and was associated with this niche. The open niche was broadcasts and the telephone was caste into the open niche as a likely area of application.

Non-experts are not likely to be distracted by such mindsets. They look at a new technology in terms of what it could help them with in the fields they know best. It was the firemen, pharmacists, doctors, hoteliers and businessmen who most accurately predicted the social implications of the telephone.

Clearly, it makes sense for one attempting to assess the future of a technology (despite the possibility of a singularity) to consider the voices of those outside their area of expertise in order to better understand how the technology is likely to be applied in their own professions and fields.

Wired for War Review

To familiarize myself with robotics and to understand what the students of the class would be exposed to, I read Wired for War in the months preceding the survey. In general, I found it to be a very revealing and engaging book. Although Singer did deal with some rather serious issues involving unintended deaths and included warnings about the dangers that robotics poses in the hands of our nation's enemies, the book projected an overall feel of excitement for what the future had to offer and was sprinkled with humor throughout. The book was not so

much characterized by its content, but by its tone. For example, a promotional quote by Jon Stewart, a famous comedian, bedecks the cover and hints at the comedic material inside.

Still, the material had shock value. You were learning that this field had massive resources being pumped into it by the military and the technology was moving so fast that things one would consider Science Fiction had happened or were about to do so. Thus, the source of the impact in ratings, especially of likelihood, can be explained. Even the space scenario did not seem far-fetched. The tone I believe most affected the desirability ratings, explaining their rise over time.

SECTION 3: METHODOLOGY

Methodology: *adapted from Fear the Robots*

Robotic technology is rapidly expanding into every aspect of our lives, and if the pattern continues this technology will be pervasive in the near future. Singer focuses on the military but also implies and warns of a future filled with machines that rule our lives, removing humans from one job after another and eventually making the population a burden on the system rather than its backbone. Singer also cautions us of a rather pessimistic scenario where our technology could exceed ourselves and could even supplant or obsolete humans. Though no one can predict the future of technological advancement with certainty, we know the debate about the man machine relationship hitting the water cooler will shape that future, in both terms of technical capability and safety regulation. Through this survey we sought to discover what people believe the direction of the technology is and whether they believe the destination of that direction is desirable and whether or not it raises ethical questions.

This study was inspired by another study proceeding our own. The previous project sought to understand what the population of WPI and several other student bodies and different kinds of local schools thought about the future of robotics. To achieve this they presented several different scenarios to the participants and asked them to rate the scenarios on likelihood and desirability. We undertook to incorporate this cross-sectional survey work by studying another similar class longitudinally. In our project investigating a relatively small class of 27, we first check to see if its initial distribution of responses mimics that of the larger existing WPI sample. Then we study change over time at certain critical moments in the class, one being right after they have read and reviewed the book by Singer another right after their participation in the mock Congressional policy debate as depicted in their final reflection papers. Hence we have both qualitative and quantitative time series data in a mix and have concluded that the qualitative reviews reflecting on the whole process are the most revealing on the process of opinion formation and change.

[Section Omitted]

In analyzing the data from the process that unfolded in the two-month class, we found a pattern emerged showing a convergence in the prevailing mindset of the students. From this we have attempted to extrapolate to the concerns of the larger WPI student population in this

ongoing and controversial debate. It is useful to know that the WPI students were not all that different in their distribution of opinions than the students from other colleges, but that is not to say that the Clark and WSU non-technical students did not have their own separate voice on key issues under study. The point is that the similarities in rating of relatively likelihood and concern were more impressive than the differences and revealed to outlines of an emerging debate about what to do when the most likely developments in a field are the least desirable ones under consideration and the consensus about this pattern goes well beyond the technically expert community.

In the words of Brauckmann (2013),

> It is beyond the scope of this study to address whether the future of robotics is actually predictable. However, it is not difficult to answer some simpler questions with methodological implications in the field of technology assessment such as: how much consensus exists among students in different fields on the direction technology is going? And if there is strong consensus on some direction, how desirable is that future perceived to be? Consensus in perception may mean the technology is not entirely unpredictable. Common expectations can even become a self-fulfilling prophesy. Such a consensus poses a significant socio-political issue, whether or not it proves to be accurate, especially if it results in an attempt to control the direction of the field, or resist undesirable outcomes.

Hence, a longitudinal study was developed to compare the first set of data with the qualitative data from observing the debate as well as the individual reflection paper and second survey.

Four scenarios describing possible futures in the progression of robotics technology have been developed. Each one posits a different lead institution providing the bulk of the developmental funding for the field of robotics. Our questions about the perceived importance of institutional influence shaping the field are answered indirectly by examining changes in the perceptions of those likely to be affected in these ways.

The underlying question to be addressed is whether members of our class, and from that all students at WPI, are actively thinking about where the field of robotics is headed, and if those concerns are mitigated by the values prominent in the mindset of the institution leading the field. This ethics question was embedded in each of the four scenarios. By this we mean that references were directly or indirectly made to Asimov's laws in each case, and it was done in a parallel and integrated way that kept it from being obtrusive. Differing reactions to the scenarios imply that it really does matter what institution is playing the lead role. The respondents assess the likelihood, desirability, and ethical implications of four possible scenarios for the future of robotic technology. The reflection papers then prove that the students went through a stage of mental development where their views expanded with a better understanding of the issues and the different views and rationales.

Developing the Scenarios: *adapted from Michael Brauckmann*

In order to determine students' perceptions of robotics technology being developed under different institutions, four scenarios were created. Each scenario posits a different institution

driving the development of robotics and each takes a different ethical stance on Isaac Asimov's three Laws of Robotics. Currently the vast majority of funding for research and development of robotics technology in the USA comes from the Department of Defense. In one scenario, this trend was continued; in the other three scenarios another institution replaced the military as the lead robotics development avenue. Each institution has a different goal for the technology; to explore and take advantage of lunar resources, to aid in meeting a major global food and environmental crisis, to take advantage of eldercare opportunities in the commercial sector, and to gain an advantage on the battlefield.

Each scenario was designed to expand the current state of robotics technology for approximately fifty years, and to picture similarly advanced robotics systems. This time frame was chosen so that the scenario would represent the contribution of the current generation of students to the field at the end of their careers. Each scenario then represents a perceived future of robotics under the leadership of varying institutions trying to address different real world problems. Each scenario is designed to raise ethical questions about the direction of robotics technology and its social and technical implications. Differing views on these implications between scenarios will reveal the effect of the driving institution.

Although they come from works of fiction, Asimov's three laws are the best known statement in literature on the ethics of robotics and the need to keep the technology under control. We adopted Asimov's framework with care. Asimov wrote his laws before the first transistor was developed, the positronic brains he envisioned and our microprocessors share almost nothing in common. As one roboticist states: "People ask me about whether or not our robots follow Asimov's laws. There is a simple reason [that they don't]. I can't build Asimov's laws into them (Singer 432)." Furthermore, the premises of Asimov's short stories are that the three laws do not entirely prevent robots from behaving in undesirable ways.

We have been very careful in adopting his framework in that it is the corporations in control of the development of robotics that are the ones following the ethical code, not the robots per se. The institutions in control in each scenario vary in their willingness and ability to accept Asimov's laws, from complete acceptance in the lunar scenario to complete rejection in the military scenario with the others falling somewhere in between. At this point in our research, there were concerns about the clarity and readability of the scenarios as well as how long it would take respondents to read through all four of them. A pilot study was conducted in a single WPI class containing about 80% robotics majors in order to obtain initial responses to the scenarios. Feedback from this class allowed for critiques that were grounded in experience and set the stage for editorial adaptation of the stimulus and response items. Following this pilot study, the scenarios were also modified to avoid confusion and to shift attention to the social implications of the technology itself, downplaying the many feasibility concerns coming from the robotics majors about how such a thing might be implemented.

Police Drone Scenario

The Fear the Robots study suggested that in any future research along these lines, the investigators should "replace the Water World scenario with another, more thought-provoking one." The weakest of the scenarios involved aquatic robots that managed the oceanic environment in efforts "to aid in meeting a major global food and environmental crisis". The team noticed that the perceived likelihood and ethical implications showed the least variation between their two surveys. In addition, it was seen overall as unlikely, which may have been the cause of the weak opinions expressed about this topic.

The team further suggested that Water World's replacement could take the form of a police robot scenario, which would "force the students to put themselves at the receiving end of [possible] robotic abuse." Indeed, the incorporation of robotic technology into everyday law enforcement was an appealing concept on which to base a scenario. The resulting Police Drone scenario imagined a world of low-altitude surveillance drones similar to modern technologies already employed in warfare. These drones carry non-lethal weaponry to incapacitate fleeing criminals. However, they were also programmed to hold fire if their intended targets displayed universal signs of surrender. Presumably, a drone taking action would be monitored and possibly controlled by a human operator anyway.

While this scenario was essentially a watered-down non-lethal version of the military scenario, it stood out from the other scenarios in that it was the only scenario with an immediate domestic application. The Moon scenario was situated in outer space, Elder Care was situated, at least initially, in China, and Military in foreign war zones. These take place far from American soil and thus are not to be encountered in daily life. Further, the surveillance aspect of the scenario raised privacy issues.

Developing the Survey: *adapted from Michael Brauckmann*

A questionnaire was attached to each scenario in order to collect data on the direction and strength of participant reaction. In the end, the hope was to produce a rank order from most to least likely and most to least desirable, with ties possible. The same indicator questions were used on each scenario to enhance comparability between scenarios and make such a rank ordering possible. The questionnaire consists of five variable indicator items: one designed to assess the likelihood of a question; two to address the desirability of the scenario in general and as an economic and technical stimulus; three more to get at the severity of ethical issues raised by the technology. One of these ethics items was left open-ended for the respondents to voice their concerns and the other item picked up on the man-machine relationship specifically to tie into the extensive literature regarding technological autonomy and control.

Each response is intended to reveal a different aspect of the participant's perceptions of a possible direction in which robotics could develop and gives an idea of what they expect to see from the technology. The study is simplified by treating the scenarios as alternatives, though in fact they are not mutually exclusive and in fact are likely to coexist and overlap. The four scenarios do not represent the only possibilities for robotics and the respondents' actual best

prediction of what will really happen is not directly assessed. Instead, this is a search for consensus on the direction of the technology and whether the social implications associated with most likely directions are reassuring or disquieting.

It was decided to keep the number of differing response categories to a minimum to avoid confusion and improve the appearance of the survey. Each question was worded such that it could be answered on either a likelihood or desirability scale. Four response categories were chosen so that there would be no middle ground. Hence, participants would be encouraged to think about the question enough to choose a side. The two response scales used on the questionnaire are as follows:

Unlikely	Somewhat Unlikely	Somewhat Likely	Likely
Undesirable	Somewhat Undesirable	Somewhat Desirable	Desirable

At this point, a walkthrough of the five items they were asked after each scenario is in order so that comments can be made about what variable the indicator is supposed to tap and what the logic was for addressing each key variable in this fashion.

The first question was "How likely is it that this scenario could come about?" This question was used to support a comparison of the four scenarios to reveal which scenario's application area (space, the seas, personal service or warfare) was perceived as the most probable direction of application and hence have funds for technological development in the field. It was important to allow for ties, so a forced rank ordering item was avoided. It is only of passing interest what the majority of the whole stratified sample considers to be most likely as the study is designed to be internally comparative. Each of the three strata, in the sample will first be considered separately in this regard. This study is designed to reveal the level of consensus between our three sample strata (robotics majors, other technical majors and non-technical (liberal arts) majors). Thus it is primarily the level of agreement within and between these groupings that is of interest. One wants to see if there is a significant consensus among these people with different academic backgrounds and literacy on the subject at hand. Then a comparison can be made with desirability to determine if the perceived most likely direction of the technology is also the most desirable. The second question: "If the scenario came about, would the resulting technology be likely to spin off many applications that significantly advance the field of robotics?" This question was developed to determine the amount of influence the technology described in scenario would have in terms of stimulating robotics and possibly other related fields. High responses on this question are intended to indicate socio-economic impact potential. However, on its face it also means that the participants see this as a promising direction of technology development that will spread outside the scope of the scenario. If a development is perceived as likely to spin off and stimulate secondary effects on society and the economy it is especially interesting from the standpoint of the coming singularity argument. While many spinoffs would not be enough by itself to support the notion of a coming singularity, as proposed in the literature and noted by Singer, many spinoff applications would be part of a singularity pattern. If a robotics advance is highly transferrable to other ends, it might usher in a dynamic and volatile period in which robotics technology could be involved in a technological revolution evocative of the singularity idea. So, perceived spinoff potential raises two questions of interest

to this study. Is the technology particularly likely to get out of control and does it matter who funds the development of the technology in terms of provoking an upheaval one might call a singularity after which developments are unpredictable? One theoretical premise of this study is that it does matter which institution develops the technology and for what purpose. However, this is in principle an empirical question subject to testing. Since the data being gathered here cannot directly address that question, it is for now a theoretical assumption, and will be tested only in the world of perceptions. I can only address the question of whether the sample believes that it matters which institution is in charge. I can also see if the respondents perceived the scenarios to have different likelihoods of generating spinoffs or not.

There are those who claim, with some justification, that technology will be applied to war whatever its initial area of development and application was. The opposite may also be true, in other words that military capabilities will soon be turned to other ends. For example, the internet was a DARPA project aimed at robust communications that could survive a nuclear war. Clearly that has not been its most significant application and it is increasingly considered a socially transformative communications medium. On the other hand, this could be an exceptional case. Most technology developed by the military is classified and subject to secrecy requirements that limit its spinoff potential, or at least delays it.

At this point we are not collecting data intended to (or in principle to be able to) resolve the questions of what the future will really be and whether it really matters what organizations fund and execute the initial development of a robotic capabilities. It is still interesting to find out if those affected believe it is important what the lead agent is and what their expectations about the future are. The perceptions of those in the field of robotics are clearly important and I would contend that the perceptions of their other technical and non-technical peers likely to be affected by these developments are also just as important. Note that we are asking only about the fifty-year period which their careers will span, and they will be acting on these perceptions at least initially. If all four scenarios are considered to have massive and essentially equal potential for spinoff, the sample is saying that it does not matter who does what and why; robotic technology is intrinsically revolutionary and possibly uncontrollable i.e. they expect that the singularity is coming.

If the scenario came about, how desirable or undesirable would the resulting changes in the quality of life be? The change in quality of life is used as a general and non-specific indicator of the effect the technology change would have on the society it is introduced into. It was important to get beyond narrow efficiency and economic implications of robotics and get into disruption and displacement issues, if they concerned the respondent. A broader-than-economics intent had to be clear, hence "quality of life" for people. A desirable effect on the quality of life indicates that the technology improves society in some way or at least alleviates the social issue it was designed to address. Undesirable responses indicate the technology may create worse problems than it solves, upset the balance in the system, displace workers or even get out of control. The key is a perception that it does not seem likely to solve problems, or that in solving one problem it might have unintended consequences that were negative side-effects and create

even worse problems. By comparing these responses across scenarios and across the three groups in our sample one can determine if a consensus exists on the scenarios most likely to have desirable outcomes and compare them to the perceived most likely scenarios. If the scenario came about, how desirable or undesirable would the resulting changes in the man machine relationship be?

Having two parts to the desirability question was an effort to separate out the major theme of dependency of people on machines and inversions in the man-machine control relationship from the many other questions risen by the movement of automation into a robotics phase (and the creation of artificial intelligence) that one could consider undesirable trends. Having two questions which could easily be combined into a composite item was a modest recognition that this was a multidimensional variable. Similar to the quality of life question, this question is intended to measure the social desirability of the scenario. Whether it is dependence on machines to meet some basic need or the formation of a caretaker relationship, the way in which machines interact with humans is inevitably changed by the kind of advancements in robotics technology under discussion. Questions of subordination and autonomy are bound to come up and thus impact the man-machine relationship that we are accustomed to seeing.

From a man-machine partnership to explore and mine the moon under lunar surface conditions hazardous to humans, to reshaping the ecology of the seas to feed humans, to directly putting vulnerable humans under robotic care, the stakes are rising. In the end, creating machines designed to hunt, ambush and kill humans raises the ultimate question of who is in control here, especially if there seems to be a trend from human in the loop to increasing autonomy in these killer bots. But all along the way to this "terminator" extreme, the man-machine relationship is one thing you want to watch, and the control issue it raises is the focus of Asimov's laws.

Whether the acceptability and rated desirability of the scenarios tracks with the degree to which the scenario violates these laws is one of the questions under study. Responses to this question will also be checked for consensus among robotics majors, other technical majors, and non-technical majors. It is not clear that WPI and Clark University students will see things the same way, as they did not in the case of nuclear power during the late 1970's. This is a matter where trust and confidence in the technology and the institutions creating and managing it become increasingly important to public acceptance.

The perception of who was in charge and public confidence in that institution, be it scientific, governmental or private industrial, greatly affected public attitudes toward nuclear power in the 1970's prior to the Three Mile Island (TMI) incident. At both WPI and Clark University there was high confidence in science as an institution, but only the WPI students perceived scientists to be in charge of the nuclear industry via the Nuclear Regulatory Agency. The Clark University students viewed the nuclear industry as a venture of the private sector, known for cost cutting in areas related to public safety.

After the Three Mile Island incident in 1979 and the Chernobyl accident in 1986 Soviet Ukraine the dynamics changed, in part due to the discrediting of all the organizations in charge of the technology. The nuclear establishment seemed not to have been worthy of public trust and

the charges of institutional failure were now specific rather than possibilities derived by analogy. In the case of the nuclear debate, the release of the film The China Syndrome, shortly before the TMI incident, had already presented the possibility of a nuclear meltdown disaster due to corporate evasion of safety regulations during the construction of a nuclear power plant. At Clark University the TMI incident moved campus opinion from 60% anti-nuclear to 80% anti-nuclear. At WPI it went from 55% pro-nuclear to 75% pro-nuclear. Hence, there was an incident associated with the polarization of opinion about this technology in that case. We seem to be in the pre-polarization period of public attitudes toward robotics as there is not yet a famous incident to interpret as evidence of how safe the technology is and why.

The WPI response may seem surprising, but it depends on how the facts were interpreted. At Clark, the key fact was that the experts said this kind of accident was highly improbable (1 in 1,000,000) and would probably never happen and yet it did. At WPI the prevailing view was that even with idiots and incompetents abusing a nuclear reactor they had not been able to make it meltdown to the point of breaching containment and harming the public. It was an economic disaster for the industry to be sure, but human error had been mitigated by built in automatic safety systems. Indeed, if all the operators had taken a coffee break when the first alarm went off and left the system alone it would have shut down safely and the emergency core cooling system would have kept the system acceptably stable. The real problems began when the operators, confused about what had happened, shut down the ECCS.

Note the temptation by technologists to design humans out of the system and make them peripheral rather than create a transparent and fault-tolerant man-machine interface and depend on well-trained and highly-paid operators. This issue is returning in the robotics debate as the "human in the loop" question about whether or not one really wants to seek fully autonomous systems. Economics push one to reduce the caliber and number of operators if possible. Other considerations push back the other way.

The robotics debate is still in its pre-disaster phase and analogy based perceptions of the institutions in charge are likely to be very important, hence the scenarios we designed move the lead role from government to various forms of public and private or entirely private commercial ventures. On the other hand, there has been a lot of science fiction literature raising concerns about this technology's development. The bulk of the nuclear power references in science fiction tended to be fairly optimistic by comparison to those about robotics, but the first nuclear application was not a power plant, but an atom bomb that destroyed two whole cities. That history of surprise, dread and the strong reassurances given the public that "Atoms for Peace" had been tamed may have contributed to the public reaction of shock when nuclear technology finally did get out of control. The experts really were not on top of things and the unthinkable nearly happened at TMI and then did at Chernobyl. So, the issues of autonomy, subordination and control, highlighted by Asimov, are the focal point of this part of the perceived desirability variable tapped by this item.

If this scenario came about, how likely would it be to raise severe or challenging ethical concerns? This item serves as a crosscheck item for the ethical concerns raised by the man-

machine relationship. Major ethical concerns may be indicated by the man and machine relationship, but it is also possible that other values, especially an environmental ethic, and possibly issues having to do with the meaning of work from various religious perspectives, have significant bearing on reactions to the questions that robotics raises for humanity. An item that asked about the level of concern provoked by each scenario that was not specific to what those concerns were, seemed appropriate. This question is an estimate of the odds that severe ethical concerns would be raised by the technology developing for the purposes indicated under the control of the given institution in each scenario.

A consensus on high levels of ethical concern would be a very significant "red flag" even if the respondents did not see the ethical stakes rising with each violation of one of Asimov's laws, as we expected. Responses to this question will be used to determine a relationship between Asimov's laws and perceived ethical concerns. This serves as a hypothetical test of Asimov's laws as ethical guidelines for robotics technology. The results of this question will also be compared with the scenarios deemed most likely to come about. In this case the two likelihood items will indicate whether the most likely scenarios are also the ones most likely to raise ethical concerns and challenges. If the current direction of the technology is deemed problematic on grounds of the emerging man machine relationship and those involved will likely be faced with ethical dilemmas, it is time to examine whether this is the direction the field or the funding agencies want to go.

Developing the Survey: *adapted from Fear the Robots*

This study validates the STS 2208 class as a model population roughly comparable to the larger data set at the outset of the class. This is more than a replication study. It makes the group interesting to study as it develops a consensus in the process of a political debate over the use and governance of these robots, as the results might generalize and reveal what is likely to happen as a broader social debate breaks out on these same issues.

It also allows one to classify a range of typical responses, such as the kinds of questions Singer raises and reveals whether these concerns intensify or are mitigated by ensuing debate with others who reacted differently at first. We will document what the policy future of the US would be if the members of this class were in charge of shaping the future of robotics and that is interesting since what they did in role as republican and democratic politicians and what they said as individuals speaking in their own voices was substantially different. In short, they do not expect the system to produce the decisions they collectively consider to be the right and wise course of action.

We consider the outcome to be a validation this course as a consciousness-raising teaching tool to expand the complexity of thought and increase the ethical consideration and understanding of the issues raised by far reaching technological change. Its value to robotic majors is evident, other majors also benefited greatly as indicated by the student's reflection and thought processes revealing in the time series data we examined. The question is whether students in all majors at WPI should have such an opportunity to consider the future of their

technical specialties? The case for doing it in one field, whether or not it is your own, and then hopefully applying those lessons and logic to the problems faced or raised by one's own chosen field, seems strong.

Watching the robotics majors as they commented about paths to the future and about charting one's career path given the alternatives was revealing. The robotic majors clearly want alternatives to working on military applications and the possibility of working on space applications was highly appealing to them. Interestingly, some of the necessary capabilities were so similar that crossover in both directions was likely, but it still mattered to them why the technology was being developed. It was perceived as impacting the likely social implications of their life's work.

Wired for War Question

Each questionnaire involved an initial yes-or-no questions that asked whether the student was familiar had already read the course material Wired for War. This question was posed in order to gauge familiarity with the modern state of robotics, at least by 2009 standards. Only one student had read the book previously, but this student also interestingly changed their opinions between the T1 and T2 questionnaires. This can perhaps be explained by the perception of a book from a recreational versus an educational setting, but I could also due to the politicization of military robotics due to recent events at the UN and elsewhere.

Data Collection Strategy

Instead of using a questionnaire, the Fear the Robots team used a coding system to measure the change in opinion following the role-playing game. Having done so, they reported many interesting perceived changes, but could not tie these back to the original survey with the scenarios. They addressed other issues, mostly those that came up in the game debate. For this study, using a questionnaire was not only more effective at producing reliable data that measured the same variables, but it was also more efficient as a technique for information extraction. Issues of validity and reliability were far less problematic in this study than the last, though this procedure did not reveal as much about the general impact of the role playing experience. To rectify that problem I decided to code the final essay- but not in an effort to get change data on the scenarios. I was interested in the process and rationale of changing perceptions, I was also curious to see if changed positions were a function of engagement in the game and the degree to which they took playing the role of their character seriously or a function of prior knowledge about the subject. I took whether they were robotics majors or not as a proxy measure for relative prior knowledge. I also acknowledge that there were some vested interests and some questions about future career prospects at play in this comparison as well. Indeed, some robotics majors made it clear that one or another of the scenarios might produce what they would consider to be their dream job. In particular, working on space technology was much more appealing than developing military technology for many robotics majors.

Sample: ***adapted from Fear the Robots***

STS 2208, the Technology-Society Debate Seminar, is a class designed to impress upon the students the importance of oversight and reasoned judgment when it comes to decision-making about the future of robotics and other emergent technologies. The continuing issue has to do with the conditions under which technology gets out of control. Escalations such as a competitive arms race emerge as classic examples. There is also a lot of discussion of the so-called "technological mentality", in which efficiency criteria trump all other considerations in deciding about whether to develop or deploy a technology.

The class develops parallels to the current situation in robotics applied to warfare from the nuclear arms race of the Cold War, citing it simply as the last arms race and most likely not the last we will see. In past years, the issue of man against machine warfare has been brought into the spotlight with all the recent US governmental activity concerning the use of drones in the "War on Terror". With its announced intension to be a debate and the tradition of there being a live role playing game akin to a model UN as part of the course, STS 2208 was a natural setting for our study. The decision to move to a US policy debate this year and have the Wired for War book by Singer be the main briefing paper for the class members shifted the class from being a promising setting for the study to being a near-perfect one. Ironically during the mock congressional debate, the UN started to take up the issue of whether the USA was guilty of war crimes for it policies on the use of UAV drones over foreign skies against foreign nationals.

[Section Omitted]

Comparing our findings to that of the previous survey we find that our sample is fairly representative of the WPI "other technical major" distribution of responses. In order to see how much impact the course readings, particularly the Singer book, had, we needed to compare our first and second questionnaire administrations which were about a month apart. It was considered unlikely that reading Vonnegut's Player Piano written in the 1950's about automation, but not robotics, or Gaviotas (which is about the appropriate technology movement in sustainable 3rd world technologies) would directly impact views on robotics. However, at a deeper level these books were about the technological mentality run amok in Player Piano and an alternative way of making decisions about technological development and deployment in Gaviotas. Hence, they could have had a predisposing effect on how one read the Singer book which was, after all, critical of how decisions about robotic technology were being made by the military.

For the purpose of monitoring change over this month of reading, we built a delta matrix of the answers by assigning a value from 1 to 4 for unlikely/undesirable to likely/desirable and subtracting the trial 2 (T2) response from the trial 1 (T1) response. These data we broke down by participant, scenario and question. In order to analyze the data, we developed four statistics. These were the percentage of participants to change their mind, (i.e. percentage with non-zero delta matrix entries) pure average of the positive and negative changes, average magnitude, and standard deviation.

For key statistics above to be interesting, a few assumptions are necessary. If the percentage of participants who changed their minds from T1 to T2 is large (over 50%) then most of the participants changed their minds during this part of the class. The average tells us the overall movement of the class, so if it is large (>0.5) there was a lot of movement in the same direction. Similarly the average magnitude tells us how much movement in general there was, a large number (>0.5) in this category means there was a fair amount of movement from T1 to T2. Finally we have the standard deviation, which tells us how well people agreed, or how close they were to average change from T1 to T2. The smaller this number is the more contiguously the group moved from T1 to T2. These metrics facilitate our analysis of the change in the perceived likelihood and desirability of the robotic scenarios under consideration by the students from T1 to T2.

Development of the Debate: *adapted from Fear the Robots*

One of the pillars of the class which we developed was a debate to help the students comprehensively understand current and future legislative processes within our system of government. This exercise was developed during and concurrently with the progression of the class. We set out to replicate a government hearing process akin to what our government would do to decide how to regulate and fund automated robotic systems. Efforts were taken to ensure the students would be able to tailor the discussion to describe some of their own views, even though they were given an agenda to portray. This was accomplished by encouraging the students to develop their own characters for participation in the debate.

The groups the students represented consisted of 6 members of the House of Representatives, 6 Senators, 4 members of the National Academy of Sciences, 4 staff members from the office of the US Ambassador to the United Nations, 4 senior staff from the Department of Defense, and 4 State Department staffers. Each group consisted of several members, often with opposing viewpoints. The Senate and House were divided by Democrats and Republicans, and each of the different groups brought their own concerns to the table. By allowing the students to model their characters off what they perceived the debate to look like, the students were forced to see the debate from various viewpoints. This amalgamation of different positions served to bring issues like defense spending, lead agency, and regulatory control into the mock hearing and the debate that followed.

Each of the groups of students was prepared in their own way by a coach in an attempt to help them best represent their characters. Each character had an agenda and sometimes they brought other agendas to the table as well. An example of this kind of activity would be represented by lobbyist, people who pay and/or bribe legislators to change their opinion on a bill of law. For instance, the team from the UN had to bring the views of the countries that they communicate with; each member of this group came from a regional “desk”.

[Section Omitted]

After the students had a chance to voice their own opinions, in role, we had the class collaborate in order to propose legislation. By accumulating the views and ideas of all the

students, we managed to condense the many individual proposals into three bills. These bills were then dissected, reworked by the class, and finally voted on. This process was to find out what the students think the government is likely to do to face these pressing new-world technological concerns and then see if that is what they really think ought to be done, but having them write reflection papers on how the game turned out and their views on robotics after having read the Singer book and participated in a debate about the issues he raised- or should have raised.

The Final Paper Prompt: *adapted from Fear the Robots*

At the culmination of this process, the students wrote a reflection paper to comment on their experiences in this class. The students cataloged their views on the future of this technology and what regulation they would impose. Second, the question of class content was scrutinized as the students commented on what portions of the class were useful in shaping their opinion. Third, the students characterized their state of mind and perspective on the robotics question as optimistically utopian or pessimistically dystopian at this point in the class. Finally, the students assessed the value and content of Singer. This all helped us to understand the student's decision-making processes.

The students were first asked to share their own thoughts. This meant that for the first time since the debate, they would drop their roles and give insight into what they are thinking on all aspects of robotics, from funding to oversight control mechanisms to what influenced their internal debate about what the best course of action would be the intention here was to try to develop a relationship between what we saw in the debate, multiple views all opposing, and what they think in a non-hostile environment. This was also an opportunity for the students to speak out as to whether they think the current direction of development toward autonomy in robotics is socially beneficial and if not where they would like to steer this emerging field of technology. The question of how they might do so was also fair game.

In the second section of the prompt, the students were able to comment on whether they believed the class was important in the shaping of their own ideas. They were also able to comment on the debate, perhaps the primary focus of the class, and indicate what views and characters changed their minds and influenced their opinions. Finally, the readings in Singer and Kelly were dissected and their relative merit commented upon. This part of the final essay speaks to the intellectual effects of the different components of this course and to the overall validity of continuing to offer general theory before jumping into the robotics debate or further narrowing the range of the material covered in this course. Narrowing and focusing would to make it more of an extended briefing to prepare for the debate and let the issue of robotics dominate the course rather than illustrate the course theme issue of how technology in general gets out of control. Further, the students were asked to comment on their mindset and optimism pertaining to the future of robotics and where it was taking us. Though the papers were semi-structured, they did not all touch on all the issues and certainly not in the same way or in the same order.

[Section Omitted]

Finally, the students were asked to give a critical review of Singer's book. They were encouraged to focus on the theme and thesis of his book and to compare it to current events in the news. We sought primarily to find out whether they believed technology shapes society or society shapes technology. This is a basic issue of control, who or what is in control of this technology and where is this technology going was a theme in the course and the goal was to see if they were taking an active or passive position on the nature of technology in general and robotics in particular.

[Section Omitted]

SECTION 4: DATA ANALYSIS

Average Scenario Likelihood

The initial questionnaire found that the Military was the most likely scenario of the four with an even 3.0 Somewhat Likely rating. It was followed by Moon and Elder Care, both of which shared a neutral 2.6 rating. The Police Drone was considered least likely with a 2.3 Somewhat Unlikely rating.

The readings between the T1 and T2 questionnaire increased the likelihood of every scenario. The Elder Care and Police Drones saw the largest increases with 0.6-level rises and were followed closely by Moon. The Military was the last in the rising likelihoods with a more modest 0.3-level.

The mock Congressional hearing between the T2 and T3 questionnaire increased the likelihood of the Moon and Military by 0.2 and 0.3 respectively. Elder Care maintained its position from the previous questionnaire, and the Police Drone scenario fell back halfway to its initial rating.

It is easily visible in the data that the readings, Wired for War in particular, made the incorporation of robotics into the scenario themes look much more probable than the students initially expected. Singer's book gave the students a perspective on just how advanced and widespread robots have become from a technological standpoint, but the post-role-playing drop of the Police Drone scenario was likely a response to the social backlash that would doubtlessly stall any such program from getting off the ground.

Mean Likelihood (Likelihood)

	Moon	Elder Care	Military	Police Drone
T1	2.6	2.6	3.0	2.3
St. Dev.	0.55	0.76	0.37	0.85
T2	3.0	3.2	3.3	2.9
St. Dev.	0.28	0.42	0.32	0.61
T3	3.3	3.1	3.5	2.6

St. Dev.	0.13	0.30	0.15	0.56

Average Scenario Spin-Off Potential

The initial responses to spin-off potential were fairly even around Somewhat Likely, but the Moon was seen as most likely with Police Drone as least likely. All scenarios had either no change or slight increases during the reading of Wired for War. By T3, both Military and Police Drone rose in response to the reading and then fell in response to the role-playing game, Elder Care stayed the same and then fell, and only Moon had increased overall by first staying unchanged and then rising in response to the role-playing game.

On the whole, responses to this item changed the least of the five. Without being in a field that would obviously benefit from similar technology, it may be difficult to gauge the potential for spin-off applications, but the broader perception was that the most ambitious program would have the greatest spinoff potential.

Mean Spin-Off Potential (Likelihood)

	Moon	Elder Care	Military	Police Drone
T1	3.5	3.3	3.4	3.3
St. Dev.	0.21	0.16	0.36	0.94
T2	3.7	3.3	3.6	3.4
St. Dev.	0.15	0.40	0.06	0.10
T3	3.7	3.1	3.5	3.2
St. Dev.	0.08	0.85	0.06	0.14

Average Scenario Quality of Life

The initial reactions to changes in the perceived quality of life that each scenario entailed varied by roughly even steps from 3.1 (Somewhat Desirable) most to 1.8 (Somewhat Undesirable). The moon was the most desirable and in order they were: Moon, Elder Care, Military, and Police Drone. The readings and role-playing increased quality of life ratings across the four scenarios, making each one modestly more desirable. Although Singer brought up mishaps that have occurred through implementation of robotics, Wired for War focused largely on positive operations, and Singer's overall attitude was that this was really cool, and might be positive if the institution supporting the activity could get control of things. He mentioned such things as bomb-diffusing, remote surgery, and even mentioned assistance with household tasks. This may have been the basis for the respondents deciding that they all could improve the quality of life more than their initial impressions had indicated.

Mean Quality of Life (Desirability)

	Moon	Elder Care	Military	Police Drone
T1	3.1	2.8	2.3	1.8
St. Dev.	0.12	0.38	0.61	0.62
T2	3.3	2.9	2.4	2.0
St. Dev.	0.08	0.36	1.04	0.21
T3	3.3	3.1	2.4	2.1
St. Dev.	0.19	0.12	0.36	0.25

Average Scenario Man-Machine Relationship

The initial opinions on the desirability of the man-machine relationship were the most varied of the four scenarios. The Moon led with 2.8 Somewhat Desirable, then Elder Care with a basically neutral 2.7 average rating, then the 1.9 Somewhat Undesirable Military, and finally the 1.4 Police Drone scenario, the lowest score given to any category in any scenario. By the class' conclusion, Police Drone had steadily increased in desirability, much like the Military scenario, but not high enough to reach the initial Military level. The Moon application was initially seen as the most positive man-machine relationship and, in comparison to the military activities in Wired for War, this impression rose sharply but then fell halfway back towards its starting level after the debate about this application in which the idea of robots building other robots came up. Elder care also had a spike involving a positive initial reaction to learning more and then a moderation of that optimism upon further reflection, although it was a less-dramatic change.

Wired for War did an excellent job in showing how closely humans and robots are capable of working together and of how robots can be an integral part of daily life. Indeed, it reported instances of a subjective bond developing between bomb-diffusing robots and their operators. There was an example of a soldier in tears bringing "Scooby Doo" to be reassembled after a blast. The experts said they would give him a new robot, but he would not accept the replacement. It had to be Scooby somehow repaired from the fragments he had gathered in a box. Robot "teammates" were being recovered by soldiers going under fire to retrieve them. After all, the robots had saved their lives more than once by reducing the number of risks they took.

Conversely, the mock Congress focused on UAVs, the negative international reaction to the American policies on their use (argued by the UN) and how damaging the perception of robots as killing machines was to the future of the field of robotics. That there had to be an image change was argued by both the National Academy of Science and the State Department. The latter was calling for a moratorium on assassinations that would not be acceptable or legal if carried out by agents on the ground. These are important factors to consider when one is a publically-elected official thinking about where a field in which we currently have a technological lead is going. In this case, the robotics majors were being asked to play the part of robotically-uneducated members of the public without a vested interest in the field.

Mean Man-Machine Relationship (Desirability)

	Moon	Elder Care	Military	Police Drone
T1	2.8	2.7	1.9	1.4
St. Dev.	0.45	0.40	0.36	0.14
T2	3.3	2.8	2.0	1.6
St. Dev.	0.24	0.22	0.67	0.27
T3	3.1	2.9	2.1	1.7
St. Dev.	0.04	0.12	0.38	0.26

Average **Scenario Ethical Concerns**

The likelihood of raising ethical concerns was viewed as differing greatly among the scenarios, but there was plenty of concern about all of them if they implied increasing autonomy of the systems and their combination with Artificial Intelligence. The "man in the loop" argument kept coming up, especially in the case of military operations. Hence, the likelihood ratings averaged the highest for all the scenarios. The Police Drone and Military scenarios were the most concerning, both of which had Likely chances of raising issues with 4.0- and 3.9-levels, respectively. Moon and Elder Care were less objectionable with only Somewhat Likely ratings.

Following the readings, Moon scenario dropped a whole level to somewhat unlikely to raise issues, the largest single change of any scenario. The others decreased slightly in likelihood of raising issues, but otherwise remained near their initial positions, meaning that the reading of Wired for War did not allay the respondents' concerns much other than making the space application look good by comparison. In the debate, some legislation was introduced which essentially said that autonomous robots that were okay in space would not be on Earth except under extraordinarily conditions that were very hazardous for humans- like dealing with a radioactive disaster.

The initial concerned responses were likely prompted by the life-dependence on robots that the Moon, Elder Care, and Military scenarios entailed, which was not something that students were comfortable with. The Police Drone scenario, while not life-threatening, had a plethora of other objections that combined to give it the poorest ethical rating, meaning it was most likely to raise issues. As noted earlier, this discomfort was mildly assuaged by the readings, especially in the Moon scenario.

Mean Ethical Concerns (Likelihood)

	Moon	Elder Care	Military	Police Drone
T1	3.2	3.3	3.9	4.0
St. Dev.	0.74	1.00	0.04	0.00
T2	2.2	3.1	3.7	3.9

St. Dev.	0.33	0.96	0.05	0.01
T3	2.5	3.2	3.7	3.9
St. Dev.	0.56	0.66	0.05	0.01

Polarization T1-T2

The readings assigned to the students had different effects on their opinions. This is especially apparent in questions where there were many response changes at the individual level, but in opposite directions so as to have little impact on the overall average. After the readings and again after the mock Congressional hearings, the most polarizing questions were the ethical concerns of the Elder Care scenario and the desirability of the Military and Police Drone's quality of life.

Delta Average and Magnitude

	Elder Care Ethical Concerns	Military Quality of Life	Police Drone Quality of Life
Delta Average	-0.18	0.07	0.14
Delta Average (mag.)	0.68	0.71	0.71

Between the first and second questionnaires, 46% of students changed their ratings yet this yielded only a 0.03 increase in the average rating, meaning that roughly equal numbers of students increased and decreased their initial ratings for the Military man-machine relationship. This question shifted up in desirability by 0.07, but that is not much with 46% of students altering their opinions. The quality of life for Police Drones and Military had the largest percentages of students that changed their minds with 64% and 54% respectively. Additionally, these two also shifted an average magnitude of 1.33, meaning that for every three students, two increased or decreased their rating by a single level, but one changed by two levels.

The Elder Care ethical concern question was even more polarizing after the mock Congress: a 0.07 increase with 57% students shifting one way or the other. The Military quality of life figures remained identical to their response after the readings. The Police Drone quality of life had identical average change, but the percentage of student shift dropped from 64% to 46%, indicating that five fewer students altered their positions.

Influential Questions

The questions that reflected the most impact (i.e. influence due to the reading) were where as many as three-quarters of the students changed their positions, opinions or perceptions. These two questions were the Moon man-machine relationship and ethical concerns. The least influential question, both after reading and role-playing, was the Police Drone ethical question with only three students (about 8 %) changing their minds for each (T2 and T3) questionnaire.

Rating Differences between Technical and Expert

After crosstabs dealing with the overall trend for the whole class were investigated, the differences or lack thereof in scenario ratings were examined and any apparent trends in opinion reported, it was time to break down the population into subsamples. In this case, I followed the lead of prior investigators who had looked at how the experts and others compared using an independence test. The proxy measure for expert was to be a robotics major.

In the initial questionnaire, the RBE majors rated the likelihood of the Moon scenario significantly higher than the others (non-RBE) Technical majors, as evident from the .41 approximate significance of gamma. The T1 Moon likelihood received a gamma value of -0.523 and a chi-squared significance of 0.220. The Robotics majors were very optimistic that this scenario would come about. A large majority of 85% believing it Likely or Somewhat Likely to occur, while the Technical majors were roughly neutral on the subject of likelihood splitting between somewhat Likely and Somewhat Unlikely. Although the class had begun with a significant difference (divided perception of likelihood between RBE and Technical majors); the difference was declining as the class learned more about current robotics capabilities. In short, the two parts of the class were converging towards a common position and there was no longer a significant difference by the end of the in class debate. The Robotics majors moderated their views a bit, but the other technical group substantially increased their ratings of likelihood.

Moon Scenario Likelihood (Expert versus Technical)

Moon	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	#
RBE T1	0 0%	2 14.3%	10 71.4%	2 14.3%	14 100%
REB T2	1 7.7%	1 7.7%	7 53.8%	4 30.8%	13 100%
RBE T3	0 0%	1 8.3%	7 58.3%	4 33.3%	12 100%
Tech T1	4 20%	5 25%	9 45%	2 10%	20 100%
Tech T2	0 0%	4 25%	10 62.5%	2 12.5%	16 100%
Tech T3	0 0%	1 6.3%	8 50%	7 43.8%	16 100%

	Chi-Squared Value	Chi-Squared Significance	Gamma Value	Gamma Significance
T1	4.42	0.22	-0.52	0.04
T2	3.73	0.29	-0.33	0.29

T3	0.03	0.85	0.20	0.57

Similarly, there was a difference of opinion initially in the likelihood of the Elder Care scenario. Again, the RBE group saw this scenario as far more probable than did the others. Since I am working with a significance level cutoff of .10 (or 10 chances in 100 of being wrong), the gamma significant level of .091 just makes the cut and I consider this a significant difference. After reading Wired for War, both groups converged to the point that there was no longer a significant difference even by this generous criterion. With a gamma value of -0.107 and a chi-squared significance of 0.337, the gamma significance level was .74, or 74 chances out of 100 that one would be wrong if one considered these two groups to differ in opinion. In short, there was no significant difference.

Elder Care Scenario Likelihood (Expert versus Technical)

Elder	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	#
RBE T1	0 0%	4 28.6%	7 50%	3 21.4%	14 100%
REB T2	0 0%	0 0%	9 69.2%	4 30.8%	13 100%
RBE T3	0 0%	0 0%	8 66.7%	4 33.3%	12 100%
Tech T1	3 15%	8 40%	6 30%	3 15%	20 100%
Tech T2	2 12.5%	1 6.3%	7 43.8%	6 37.5%	16 100%
Tech T3	1 6.3%	3 18.8%	7 43.8%	5 31.3%	16 100%

	Chi-Squared Value	Chi-Squared Significance	Gamma Value	Gamma Significance
T1	3.46	0.33	-0.42	0.09
T2	3.38	0.34	-0.11	0.74
T3	3.68	0.30	-0.31	0.32

On the desirability of the Elder Care scenario, both groups expressed similar views on average: the majority considering it “Somewhat Desirable”. There was no significant difference indicated by the 0.012 gamma value with a significance of .97. Following the readings and role-playing, not a single member of the RBE group found the scenario undesirable, while the other Technical majors remained tepid or ambivalent and exhibited more scatter. Hence, the positions diverged and the difference became more evident with a -.52 Gamma correlation value indicating a strong relationship between major and likelihood rating. However, given the small numbers

involved, the 0.11 gamma significance level is just short of my .10 requirement to declare it significant. So this difference, though robust, may not be "real" in the sense that if you say it is you would be wrong 11% of the time, not 10% of the time as I require. The chances of it generalizing beyond this sample to the larger WPI population is also iffy with a 0.24 chi-squared level of significance meaning that the differences you see in the table might not be present in the broader population 24% of the time.

Elder Care Scenario Desirability (Expert versus Technical)

Elder	Undesirable	Somewhat Undesirable	Somewhat Desirable	Desirable	#
RBE T1	2 14.3%	2 14.3%	8 57.1%	2 14.3%	14 100%
REB T2	1 7.7%	1 7.7%	7 53.8%	4 30.8%	13 100%
RBE T3	0 0%	0 0%	8 66.7%	4 33.3%	12 100%
Tech T1	2 10%	3 15%	13 65%	2 10%	20 100%
Tech T2	1 6.3%	3 18.8%	10 62.5%	2 12.5%	16 100%
Tech T3	0 0%	3 18.8%	10 62.5%	3 18.8%	16 100%

	Chi-Squared Value	Chi-Squared Significance	Gamma Value	Gamma Significance
T1	0.34	0.95	0.01	0.97
T2	1.91	0.59	-0.35	0.26
T3	2.85	0.24	-0.52	0.11

The Military scenario's desirability rating was subject to a similar shift in ratings: agreement between both parties that was a roughly neutral standing without a significant difference. Indeed, they were essentially indistinguishable patterns of response with a 0.92 gamma significance and a 0.77 chi-squared significance.

Consensus had broken down and the two parts of the class diverged. By the final survey following the role playing game, three-quarters of the Technical majors found the scenario "Somewhat Desirable", while a solid majority, 83%, of the RBEs were inclined to view this scenario as at least Somewhat Undesirable. The T3 gamma significance was 0.165 and the chi-squared significance was 0.07, showing a non-linear relationship below the 0.10 cutoff and therefore the difference was to be considered really there.

Military Scenario Quality of Life (Expert versus Technical)

Military	Undesirable	Somewhat Undesirable	Somewhat Desirable	Desirable	#
RBE T1	3 21.4%	4 28.6%	6 42.9%	1 7.1%	14 100%
REB T2	3 23.1%	2 15.4%	6 46.2%	2 15.4%	13 100%
RBE T3	2 16.7%	5 41.7%	5 41.7%	0 0%	12 100%
Tech T1	6 30%	3 15%	10 50%	1 5%	20 100%
Tech T2	5 31.3%	3 18.8%	7 43.8%	1 6.3%	16 100%
Tech T3	3 18.8%	1 6.3%	12 75%	0 18.8%	16 100%

	Chi-Squared Value	Chi-Squared Significance	Gamma Value	Gamma Significance
T1	1.12	0.77	-0.03	0.92
T2	0.81	0.85	-0.23	0.43
T3	5.29	0.07	0.42	0.17

The readings redefined the ethical implications of Elder Care by changing it from a semi-random distribution to one in which polarized RBE and other Technical majors. Both groups had initially found the Elder Care scenario to be very concerning, but while the Technical majors maintained this position, the readings had caused the RBE majors to warm to the idea of robotics in the capacity of elderly assistance. The T3 chi-squared significance was 0.957 and the gamma significance was 0.568. The RBEs substantially decreased their ratings of the likelihood of raising ethical issues to indicate only an average of "Somewhat Likely". The two significance tests differ in significance estimates. When the chi-square is not significant (.12) and the Gamma correlation is significant (.08), it usually means that there is a linear pattern evident in the table based on the sample data but it is not strong enough that we can be sure it will generalize to the larger population from which the sample was drawn. However, in this case, the difference is not large and so with odds of being wrong 12% of the time if I claim it will generalize, I think the finding is really there in the general population and the sample has picked up on it. The debate in the mock Congress led the other technical majors to shift their views in the direction that the RBE majors had already moved. Thus they reunited in consensus at the end that this scenario was less ethically-fraught than it had initially seemed to both parts of the class. The linear relationship is clearly gone and the existence of any difference is now questionable.

Elder Care Scenario Ethical Concerns (Expert versus Technical)

Elder	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	#

RBE T1	1 7.1%	1 7.1%	3 21.4%	9 64.3%	14 100%
REB T2	1 7.7%	3 23.1%	6 46.2%	3 23.1%	13 100%
RBE T3	1 8.3%	2 16.7%	4 33.3%	5 41.7%	12 100%
Tech T1	2 10%	2 10%	5 25%	11 55%	20 100%
Tech T2	2 12.5%	1 6.3%	3 18.8%	10 62.5%	16 100%
Tech T3	1 6.3%	1 6.3%	6 37.5%	8 50%	16 100%

	Chi-Squared Value	Chi-Squared Significance	Gamma Value	Gamma Significance
T1	0.32	0.96	-0.17	0.57
T2	5.86	0.12	0.46	0.08
T3	0.87	0.83	0.20	0.52

The quality of life ratings of the Police Drone scenario had a similar short-term divergence; both groups were somewhat split between "Undesirable" and "Somewhat Desirable" in the initial questionnaire with no significant difference. The readings produced a significant difference of opinion as the other Technical group's average ratings dropped and the Robotics majors were considerably more likely to see some quality of life improvement, noting the perspective of the victims of crime rather than the perpetrator rights. By T2, there was a strong 0.49 gamma correlation of ratings by major and the significance values had dropped to 0.09 for gamma and 0.24 for chi-square. Thus we have a significant relationship in the table based on the sample but it might not generalize. The role-playing game exposed the other technical majors to the RBE perspective and they moderated their views. Hence, over time, both groups warmed to drones assisting the police (a man in the loop was considered essential) and brought them back to agreement but in a more positive view of this scenario. Thus, there was no significant difference at the end, but there had been at the mid-point of learning more about robotics and the issues it raises. The RBE majors shifted first, based on individual reading, and then maintained that position through the debate. The other technical majors maintained their position through the individual reading but shifted later based on discussion with their peers.

Police Drone Scenario Quality of Life (Expert versus Technical)

Police	Undesirable	Somewhat Undesirable	Somewhat Desirable	Desirable	#
RBE T1	6 42.9%	2 14.3%	6 42.9%	0 0%	14 100%

REB T2	2 15.4%	6 46.2%	5 38.5%	0 0%	13 100%
RBE T3	2 16.7%	6 50%	4 33.3%	0 0%	12 100%
Tech T1	10 50%	4 20%	6 30%	0 0%	20 100%
Tech T2	5 31.3%	9 56.3%	2 12.5%	0 0%	16 100%
Tech T3	3 18.8%	11 68.8%	1 6.3%	1 6.3%	16 100%

	Chi-Squared Value	Chi-Squared Significance	Gamma Value	Gamma Significance
T1	0.63	0.73	-0.18	0.54
T2	2.89	0.24	-0.49	0.09
T3	3.98	0.26	-0.28	0.40

This example is particularly valuable in making the point that process matters and a longitudinal look at opinion and perception formations is revealing. In this case, one has uncovered what I think is an opinion leader phenomenon. It is how changes by a small percentage predict what the general populations will think later. Usually this refers to the college educated shifting before the less educated part of the population, as they did on the perceived safety of nuclear power plants.

T1-T2 Rating Differences from Previous Studies

In the Moon scenario from the Fear the Robots study, the students who shifted their opinions did so in a unidirectional manner for both the quality of life and ethical concern categories. The readings had a greater effect on the Fear the Robots students and shifted their opinions upwards 0.66 for desirability and down 1.25 for ethical concerns, a larger movement than the respective 0.25 and 1.0 for this study, in which students shifted opinions both positively and negatively for both questions. The differences in this study were both within half of a standard deviation of those of the previous study. The Moon ethics question saw the most changed opinions with over 91% of the class altering their rating toward fewer ethical concerns in Fear the Robots.

Although there was little change in the Military desirability and likelihood to raise ethical concerns ratings in both studies, the Fear the Robots students saw the Military scenario slightly less desirable and slightly more concerning toward the end, the opposite of what happened in this study where concerns moderated. On the other hand, the Military was the most extreme on the undesirable scenarios in that study and the Police Drones took over that position in this study.

The Fear the Robots study found the Elder Care scenario less desirable after further consideration by a 0.08-level, while the students from this study gave the same scenario a 0.14-level boost in desirability upon further consideration. It is too bad that they had such a low response rate at T2 since that means that they can rarely report a significant finding. However, the trend being different is interesting. It indicated in what way they are different if they are different.

The aforementioned differences were the only ones worthy of note. In general, the previous study and this one replicated in the sense that they produced roughly equal shifts in opinion, as could be expected when exposed to identical reading material and similar discussions, at least in format.

Final Reflection

In their final reflection papers, most students admitted that, after reading Wired for War, they were shocked by how much more likely the scenarios now appeared to them. This shows the power of Singer's book even four years after its publication. At the same time, students were skeptical of the ability of the American government to impose the necessary regulations until it is too late to do so. Neither did they trust the government to "shift funding of robotics away from military application and towards civilian uses." One student used the analogy of North Korea to express that "even our government's best efforts in restricting nuclear weapons have not stopped Iran and North Korea from making their own." Another excellent analogy stated that "…the government only really started taking the societal implications of the internet seriously in 2003. The internet is beyond any single entity's control and the lack of regulation during its most fertile period led to this instability."

These examples show how easily a neglected technology can spread out of its parent nation's control and into the grasp of its enemies. The students called for a shift in government that is "not necessarily a technocracy, but at least a system that takes more heavily into account the views of experts." Interestingly, students that still saw the scenarios as unlikely tended to not give detailed reasoning behind their belief, but students that saw them as likely often provided very specific reasons or close analogies to express their thoughts. One student noted that, at least for American citizens, "there are ethical concerns with robots killing humans, but when it's done in war it doesn't become much of a social issue."

The question is whether a war on terror is really a war, since there is no foreign power to declare war on. Is it really a matter for INTERPOL and other international law-enforcement agencies? In the case of nuclear arms, it was clearly the balance between nations that was at issue and countries could hold the population of their adversaries hostage. Indeed, the policy of MAD, Mutually Assured Destruction, was what kept the Cold War from heating up despite proxy wars in Korea, Vietnam and Afghanistan. The use of the military to go after terrorists in the wake of 9/11 set something else in motion that will have far-reaching consequences.

SECTION 5: CRITIQUE

The Questionnaire: *adapted from Fear the Robots*

The questionnaire the students answered consists of four distinct scenarios and five questions asked after each scenario. These questions are posed so as to gain insight into the correctness and desirability of each of the scenarios. These questions are the same for each scenario in order to provide continuity throughout the survey. By administering the same questions for each scenario bias in the magnitude of results between scenarios is limited. The answers to the questions were limited to four possible responses. Limiting the responses allows for easier development of a quantitative metric for opinion. However, limiting responses to the questions to four possible categories inherently affects the responses received.

Some of the differences in the strength of the opinion are lost. For example, two people responding to question one may answer "Likely", when in reality one person believes it to mean an almost certainty, whereas the other could intend this to mean that it is one of ten likely possibilities that are equally possible.

In an attempt to limit the effects of this type of bias in the study, the change in the results of an individual over the course of two surveys is examined, instead of attempting to extrapolate assumptions about the sample from the results of one survey. Another possible loss of information in the range of opinion arises when a person's opinion changes but not enough to warrant a change in the answer category. An example of this would be an instance where the first time taking the survey a subject answering question one selects "Somewhat Likely" after attempting to decide between "Somewhat Likely" and "Somewhat Unlikely." The second time the subject takes the questionnaire they again answer "Somewhat Likely" though their opinion has changed and they now are trying to decide between "Somewhat Likely" and "Likely." The subject though they did select the same answer has changed their opinion, however the subject still believes "Likely" is too extreme as it is the strongest answer available in favor of a response of likely.

This leads us to another example of this type of bias. In this example the respondent is already as extreme as our response categories allow and their opinion becomes more extreme. This situation may have occurred with the military scenario almost no one changed their answers to question five however almost everyone had already picked the most extreme answer possible "Likely". Though this specific example occurs over the entire sample, it allows us to develop conclusions from this. It can also occur on an individual basis and the study is unable to pick up this change of opinion.

It is for biases such as these that the final questions were provided. "Please comment on the scenario (If you had any trouble with the questions above, please note it here as well)". The idea of this space was to allow the subjects to comment on biases they perceived in the questions. However, the students were not asked to actively attempt to rate the change in their opinion from survey to survey.

[Section Omitted]

Thus, if their opinion changed to be more extreme than it already was and they had already chosen the most extreme answer they may not have thought to mention it in the comments section.

Though there can be biases inherent in the questions asked as well. The first question asked about each scenario was: "How likely is it that this scenario could come about?" This question was intended to gauge the likelihood of robotics developing in the direction indicated in the scenario. The hope was that students would examine the type of issues robots were being applied to, and what institution was charged with control of the development of robotics in each scenario. However, the question might easily be misinterpreted to mean the technical feasibility or implementation of the specific application being discussed.

[Section Omitted]

This leads to the next issue. That is many conditions including application, institution in control of development, and the extent to which Asimov's laws were followed changed between the scenarios making it difficult to determine which conditions the students found most likely.

The second question asked of each scenario was: "If the scenario came about, would the resulting technology be likely to spin-off many applications that significantly advance the field of robotics?" This question was originally intended to gauge the likelihood that the type of robotic technology described in the scenario would stimulate further development in robotics and other related fields. The words significantly advance leads to some ambiguity as to what constitutes a significant advance. Though this question was helpful in the previous study in looking at the possibility of a singularity occurring, it is not helpful in this study. We are looking at what people believe the direction of the technology is and whether they believe the destination of that direction is desirable. Another of our concerns is to assess the level of consensus that exists among students in different fields on the direction technology is going. Due to these concerns, this question was not included in the analysis, though the data was collected to facilitate comparison of our sample responses to those of the prior study.

The third question asked after each scenario was: "If the scenario came about, how desirable or undesirable would the resulting changes in the quality of life be?" This question was designed for the original study to be an indicator of the effects of the technology described in the scenario on a society beyond any economical or efficiency implications. If we assume that a desirable or undesirable change in "quality of life" can indicate desirable or undesirable direction for robotics development. This question can be useful to this study in determining whether students believe the direction of development in the scenario is desirable. However, this is an assumption based on reasoning; the question dose not directly ask how desirable is the direction of robotics in the scenario is.

The fourth question in the series was: "If the scenario came about, how desirable or undesirable would the resulting change in the man machine relationship be? The intention of this question was to look at the desirability of man's dependency on machines in scenario and the desirability of the control relationship between man and machine. This question asks about the

desirability of changes in the man machine relationship. It also left open the option that one may believe that the relationship may not have changed but is still undesirable or desirable.

The man-machine relationship describes the relationship between man and the machines man creates such as a dependence on machines to meet some basic need or the formation of a caretaker or regulatory relationship in which a human is under the supervision of a robot. However, this definition of the "the man-machine relationship" is not clearly stated in the question and may have created significant misinterpretation of the question. Many students questioned after the completion of this survey were unable to describe what "the man-machine relationship" in the question meant. The question serves the ends of this survey best by assessing the ethical concerns that develop with robotic technology; however this question is addressed more directly in the final question. Due to these concerns, this question will not be included in the analysis.

The fifth and final quantitative question asked after each scenario was: "If this scenario came about, how likely would it be to raise severe or challenging ethical concerns?" This question was developed in the original study to serve as an indicator of the feasibility of Asimov's laws as ethical guidelines for robotics. In each of the scenarios, Asimov's laws were applied in varying degrees. Though more affects the results of this question than just degree to which Asimov's laws are followed, the result of this question can be affected by many parts of the scenario. Possible factors include the dependence of man on robots, the global and environmental effects of the scenario, and the social effects or changes the scenario might indicate. However, these factors make the results apt to being applied to the evaluation of the perceived correctness of the direction presented in the scenarios. This evaluation can take place if a scenario that is less likely to develop severe ethical concerns is considered more socially correct and a scenario that is more likely to develop severe ethical concerns is considered less socially correct.

Police Drone Controversy

From an objective viewpoint, the Police Drone scenario should have been an improvement to the quality of life when compared to the Military one. However, the participants responded both more strongly and more negatively to the Police scenario that took place domestically despite its being a non-lethal technology. Objectively, it raised fewer ethical issues than military use of the same technology and its associated collateral damage, but was so objectionable that it was also considered less likely than the other scenarios. Clearly, the reason for this unlikely rating was not technological capability.

Hence, the findings from last year are harder to assess for replication than they would be if the scenarios had not been changed, but the responses to the changes are revealing.

Both the Brauckmann and Fear the Robots studies had observed, hypothesized, and concluded that the most likely scenarios were also the least desirable, such as Military, and that the most desirable scenarios were among the least likely, in this case the Moon scenario was the one that got all the attention but the Water World scenario was the least likely. Thus, they

considered themselves to be initiating a debate on how to change the odds. However, technically, the lunar scenario was not considered to be the least likely, it was just considered much less likely than the military scenario and about the same as the health-related scenario. The difference was rather one of enthusiasm since the robotics majors really were responding strongly and positively to the space application as the one they hoped to work on. Not only was it exciting and pioneering, it raised the fewest ethical issues and produced the best man-machine relationship of the given alternatives. Hence, the military-space tradeoff comparison emerged as focal point in the role playing games.

This trend was expected to continue as this theory had remained true for both previous studies. However, the new Police Drone scenario broke this pattern by being both the least desirable and the least likely. In fact, it was also rated as the least likely to generate spin-off technologies, and as the least-desired man-machine relationship. There was near-unanimous agreement that it was most ethically-concerning.

As the Police Drone scenario was expected to be a more conservative use of this quickly developing technology compared to the military application, the student reaction was shocking. On its face, this was not a radical proposal compared to robotic killing machines and it surely seemed more likely on technological grounds than the space or health scenarios. .

When their data was reviewed in class following that of the initial questionnaire, the students were asked to voice their objections to the police scenario and their reasoning behind them. I began the discussion by stating what my initial expectations for the results had been and explained that, in an objective sense, that the surveillance drone scenario should have been more appealing than a military one.

Most students were very vocal and prepared to defend the views revealed by the data analysis. They were confident in their stand against law enforcement drones on political and ethical grounds. Premises included distrust of law enforcement coupled with the belief that the military is more accountable than domestic police, or that the presence of surveillance drones would only increase crime analogous to the conditions of the American Prohibition. Others claimed that all technology is inherently imperfect and Americans should not be victims to any potential mishaps. Further reasoning stated that the use of drone technology against American citizens is unethical and that insurgents and terrorists should be the only subjects legitimately to be hunted down because they have distinguished themselves as enemy combatants. There were also concerns that surveillance drones could become oppressive tools of the government in the event of a popular revolution. Only one student stood out from the rest of the class and echoed my personal view: the fact that drone technology when applied to everyday Americans will create more controversy than harsher technology used overseas and outside of the public eye. It was a matter of public awareness and who was at risk rather than ethical grounds in the larger sense of the word

Role-Playing Game

The role-playing game differed from that of the previous study in at least three ways. First, both Professor Craig Putnam and I played took on roles of Congressman Lamar Smith, chairman of the House Space, Science, and Technology committee and his staffer, respectively, in comparison to the way sociologist Peter Campisano, of the Army War College played this role. We were very actively advocating for a space program focused on Mars. Previously, only Professor John Wilkes was openly an advocate and was in favor of the construction of a base on the Moon. Last year, he was able to influence the direction of student conversation within the Senate as his character, Chairman Senator Jay Rockefeller. On the other hand, he did not prevail in the vote due to the excellent coaching of the DOD team by Campisano. The DOD team was advocating the actual plans being developed by their real-life agency. Having done that, Campisano could just sit back and watch the show. Having other influential characters across the aisle and within the other legislature better enabled Professor Wilkes to keep focus on the proper topics of discussion and avoid trivial distractions. He also avoided any of his controversial comments the year before about NASA doing the R&D for the moon mission and then turning it over to private industry in the form of Lunacorp to reap the profits. With a high-profile name like Rockefeller, the class did not trust his motives. Actually, NASA would like to do that. The NASA technologists see themselves as being in an R&D organization, not an operational agency.

Secondly, this study was intruded upon by the introduction of the unofficial Mars scenario, also known as the Phobos First scenario. This involved a presentation by an outside group of students, who adopted NASA roles from a well-regarded NASA center and claimed to have been tasked with working out a Mars mission. In testifying to Congress, as NASA they added an important new element to the game. The case for the benefits of a manned mission to establish an outpost on the Martian moon of Phobos and the lunar mission scenario pulled the whole debate in the direction of a space policy debate rather than a robotics policy debate.

The Phobos presentation was followed by two short surveys modeled after the questionnaires used in this study. While this in itself was not detrimental, the lasting effect of this intrusion was in how it shaped the following role-playing game. With the addition of an alternative space option, the question morphed from whether or not a space mission was worthy of increased funding (and NASA being a co-lead agency in robotics with DARPA), but which space mission should be chosen from the two for the most return on investment.

In the previous study, the Moon scenario was generally viewed as extreme (some would say a far-fetched) way to end the energy crisis. In the end it, it was turned down in a close vote. When presented with the even more "extravagant, bold and outlandish" Mars scenario that offered no financial return, the Moon scenario looked relatively moderate, practical and thus attractive by comparison. When this is considered in conjunction with the fact that Lamar Smith and Jay Rockefeller were each stubbornly arguing for different space options, the concentration of the entire role-playing debate became which space mission was superior, discussion, though it

was still the military budget that was going to be affected by a policy change in the direction of space. The other three scenarios fell largely by the wayside. It was barely noticed that the effect of shifting funding from the armed services to space would bring half of the robotics program under the control of these two Science committees. At present, their influence is modest since there is a Armed Services committee and thus it has jurisdiction over a major science and engineering R&D budget in the robotics area , but barely cares about it given the other military issues and expenses it has to deal with. That Lamar and Jay were both playing politics and empire-building was not a matter of debate, though Rockefeller was directly accused of this last year.

Based on this event, it is expected that the Moon scenario would be thought of as more likely given the context and the neglect of the other applications of robotics within the role-playing discussion. It was Military versus Space.

Third, the withdrawal of the Water World scenario and the inclusion of the Police Drone scenario offered a controversial new topic to be thrown into the mix. While the Water World scenario was quickly written off as too complicated and unnecessarily disruptive of the balance of aquatic environments, the Police Drone scenario had many advocates. This round of play specifically added characters in the Department of Homeland Security, an agency that was not officially part of the mock Congressional hearings of the Fear the Robots study though one student argued that case at his own initiative, though ostensibly on the State Dept . His focus was border security. Furthermore, these Homeland Security characters later mutated into Congressmen and Senators on the House and Senate Homeland Security committees, so their views could not be ignored.

In short, this was a very different game and hence the experimental stimulus or intervention variable was not the same. Luckily my theory only called for an experience in which the participants got to debate the issues with their peers. At that level, it was comparable. But the new scenarios are a factor, especially the Mars testimony.

In the opinion of Professor Wilkes, the mock congressional debate differed greatly thanks to the strength of the testimony delivered by the five committees. His opinion was that the Fear the Robots debate was much more strongly argued by nearly all committees that participated, but that the majority of the committees in this round experienced shortcomings that left the debate imbalanced.

The previous debate had seen the DOD retain its entire budget thanks to the strong lobbying of that agency, one member of which had also stressed the importance of the military connection to homeland security. By contrast, the DOD in this debate was very weak; the unquestionably weakest of the five and this was surprising since they had read a whole book that served as a briefing paper. Their opponent, the United Nations committee, was the polar opposite and was the undisputed strongest. The State Department also made the DOD look bad. This imbalance set the stage for a reduction in military spending to foster a robotic R& D effort as part of the space program once the committees decided which one to endorse. The chosen space mission would be funded at the expense of the military budget. Furthermore, the military's moral

position would be challenged by the United Nations' values and views on the American policies governing the use of UAVs. This would frame the debate instead of having a more evenly matched argument on a level playing field.

SECTION 6: DISCUSSION OF RESULTS

This study is a second iteration of a similar longitudinal study of 12 subjects in a Worcester Polytechnic Institute class on Science, Technology, and Society. Four scenarios were presented to students and their assessments of likelihood, spin-off potential, quality of life, man-machine relationship, and ethical concerns for each. The previous study began with 27 participants, but only finished with 12. This study began with 34 and ended with 28, a much better response rate and a larger N (number) for statistical purposes.

Summary of Results

Although both the Fear the Robots and the Brauckmann studies concluded that the most desirable scenarios were the least likely and that the most likely scenarios were the least desirable, this study, with the inclusion of the Police Drone scenario, has upset this nice neat description. The reality is more complex and highly dependent on the mix of scenarios. I wrote a new one considered both undesirable and unlikely, even compared to the military use of the same technology. This change can be attributed to the domestic environment in which this Police Drone operates. This struck close to home, which was not a major factor in previous surveys. In the prior questionnaire, the scenarios place the action in a remote location and so Americans are not the first populace to be subjected to the testing of these situations.

The longitudinal change coupled with related education and policy interaction has revealed a flaw in the theory of selective perception. It is also notable that between the readings and the mock Congress, another shift in opinion occurred that caused certain ratings to slip slightly backwards towards their original values. The political characters taken on by the students were acting based on the 'national poll data'. These mock "poll" data were taken from the students' own answers to the T1 questionnaire, but only the percentages were used to pretend that the data was representative of national technical and robotics experts. While the characters had their own opinions, they had to respect "the voice of the people", those who would be hopefully reelecting them in the future. Indeed, the social backlash affecting Drone use both abroad and at home was high on every politician's mind when considering the proposed bills. To some extent, the perception was that the military had gone too far and had to be reined in, and the use of this technology domestically would have to be much more carefully examined than its' use overseas had been. The technical experts, on the whole, did not disagree with this general stance, though on particulars they did and that ended up influencing the T3 results.

Overall Conclusion:

The goals of the team that studied the same class last year and myself were essentially the same. This was to answer the question about whether an unexamined opinion or perception is stable as one starts to look into it and it becomes politicized and debated in public policy circles? What was interesting about this course and what made it a suitable setting for such a study is that it had two distinct activities one might expect to change perceptions and opinion built into it. Specifically, it included as a required reading the book Wired for War by Singer (which was the inspiration for one of the scenarios). Although this was being used as a briefing paper for a policy debate on the future of robotics, I decided to reissue the perceptions instrument before the debate began and then again after this six hours event spread over three days.

The policy debate was done in "role" as a game and the class members participated by giving testimony to Congress, and others by taking testimony and converting it into a proposed legislative or budgetary bill.

On the written advice of the prior research team, I asked the instructor to reissue the questionnaire and drop the idea of a final take home exam requiring instead a final reflections paper. We (the prior team and I) both wanted to see the students drop out of role and in their own voice give their opinion about what the important issues were and how they should be addressed. We also got him to introduce the findings of the prior study into the class so that the core issue of what to do if the most likely scenarios was not the most desirable one could be addressed directly. In return, we offered to rapidly process the results of the class when they were administered the same instrument so that they would have their own data as a starting point for debate. In fact, the views of the class represented a more extreme version of the prior results. Now that they had these findings before them it was possible to present their own findings as the views prevailing in Congress and the large study findings as representing the pattern of perceptions and opinion in the general population. Thus presented, it was possible to build in a part of the role playing game in which the professor(in role as Jay Rockefeller) justified a proposed bill as in alignment with the public opinion data available to them on the subject.

With all this in place, we could concentrate on making sure that those who did not want to write their own roles got fully developed ones and that we were ready to systematically observe the class. I intended to assess questionnaire change on the scenarios they favored and questioned the wisdom of concurrently with the launch of the role playing game.

Our logic was to gather initial data, then re-administer the questionnaire after they read the book by Singer but before the role playing game, and have the reflection papers written after the game so that people could reflect back on and report the whole process of coming to decision on this issue. True, it was compressed into seven weeks rather than a normal process of learning about an issue via reading and the media over a longer time, but there were clearly stages in a process to examine. One could use these data to test the theory of selective perception. I was convinced that positions would change as people got to know more and processed the information in public debate amidst a diversity of views. However, theoretically, people should not change their positions, but rather selectively hear or retain only the information consistent

with their initial views and get better and better at defending them and more committed to them over time.

This approach proved to be very revealing and, as it turned out, positions do change, but it is not a clean and predictable process. Some people were moving in one direction while other moved in the opposite direction. If you looked only at averages, you would greatly underestimate the amount of position shifting going on.

[Section Omitted]

One cannot be certain that the process we observed is what will happen in the real world as the challenge of controlling robotics technology so as to get socially beneficial outcomes clarifies and is debated in Congress and elsewhere. However, one does get a hint about how broad a consensus is likely to emerge that something needs to be done and there are clues about what the common ground will be among those espousing different positions.

There will be an effort to restrict the autonomy of military robots and keep humans in the loop despite arguments that robots will be more likely to follow order to spare the innocent and noncombatants than human soldiers trying to protect their own lives. Also, an effort will be made to diversify our investments in robotic technologies to include other than military applications, though not a call to reduce the total amount of spending on the field. This is quite substantial but considered a key to the future. Thus the problem will be defined as more institutional than technical and a political response through regulation and funding controls that result in robotics money moving from the control of DARPA to other lead agencies in the government is likely. However, new capabilities developed for civilian use will clearly be available and sometimes adopted and applied by the military.

From a military perspective there is an interesting tradeoff in losing control of funding. On the one hand, the defense budget no longer has to carry the brunt of the robotics R and D effort and can shift money to other priorities. On the other hand DOD loses control of what is in the public domain as the military can longer develop and then "classify" robotic advances to keep them secret.

Interestingly, both robotic experts and non-technical professionals will be more comfortable with these developments than technologists in other fields who tend not to see the controversial applications as being so ethically questionable as people in the field and in fields like law, medicine, business, politics and the arts.

The case for having WPI students entering the technical professions, and especially robotics majors, experience this kind of course is very strong.

[Section Omitted]

It also fulfilled a graduation requirement for robotics and computer science majors. Key to the success of the course was having enough coaches for the role-playing game and being sure that all of them role playing members of key power groups understand the DOD and Foreign Affairs as well as the Republican world view.

[Section Omitted]

It is also not clear that the Singer book will be a suitable core for the course for many more years as it is already starting to feel a bit dated in terms of technical capabilities. Still, most robotics majors gave it good reviews and the people of other majors found it invaluable.

SECTION 7: FUTURE WORK

Recommendations for Future Studies

These studies have been conducted without a control group. For the purposes of error estimation, it would be beneficial to have a similar study conducted without the increasing supply of relevant information and with the same interval between questionnaires. As it turns out, UAVs were in the news during the game much less the whole course and this may have had an unmeasured impact on the change variables.

As there were notable differences in how the RBE majors and the technical non-RBE majors reacted, based on the changes documented by the questionnaires, it would be interesting to somehow include non-technical majors into the study, although I have no obvious means of implementing this suggestion.

As the first questionnaires were being completed by the students in class, I was struck by the thought of whether the order in which the scenarios had been presented would affect the student answers. Particularly, I was worried that placing the Police Drone scenario before the Military one might cause an overreaction to the Police Drone scenario. If the students gave the Police Drone scenario the highest possible ratings only to find the Military scenario even more objectionable, then there would be no way to express their sentiment within the confines of the rating system. However, the less-extreme ratings on the Military scenario confirmed that the Police Drone ratings were not an unintentional over-reaction. Still, I wonder whether placing the Military scenario before the Police Drone scenario would have an effect on their bias towards domestic robotics. It is up to future teams to decide whether this minor change is worthy of investigation.

SECTION 8: APPENDICES

Selected Moon Comments*:* T1 *T2* T3

"The last few lines indicate there could be war between robots, leading to war no longer fought by humans."

"One thing touched upon by the scenario was robots that can build other robots. I think this is a common situation in thought exercises about the future of robotics. This autonomous reproduction, as well as the conflict for resources, poses the greatest ethical concerns. If handled properly, it could increase humans' quality of life."

"The scenario in general seems to be ambitious in both the technology level and economic level of the future. It doesn't seem very realistic."

"This scenario takes place too close to the present."

"Hopefully, we will never need to mine minerals on the moon, but this scenario could lead to a war over lunar property rights."

"This is unlikely to occur due to the fact that space exploration is going down in popularity in terms of which programs are getting funded. Robotics is more likely to be used to make Earth processes easier."

"Currently, people are pretty skeptical or afraid of robotic technology, especially autonomous systems. There will have to be a lot of persuasion, demonstration, and advertising before this scenario is possible. This scenario, however, seems to be pretty likely, but not by 2030."

"International conflicts with resources have always facilitated war, so such large-scale operations will create international tension."

"I believe the environmental impact would be most concerning. Automation through robotics is not an ethical concern yet with respects to resource harvesting and processing, nor do I believe it ever will be. The particular application in the environment will be the concern."

"Resources from moon is a good thing, but competing for resources on moon would very likely result in conflicts on Earth between countries, which is bad."

"My friend interned at NASA working on autonomous fleet robots."

"This scenario seems to be approaching, based off my knowledge of WPI's recent success in the NASA competition."

"Still seems like the best scenario [of the four]."

"Reading Wired for War made me think of this as being more likely to happen—exponential growth of technology."

"This would deliberately increase a national sense of competition."

Selected Police Drone Comments: T1 *T2* T3

"This would be extremely controversial. Both 'undercover' robots and army robots would not go so well with some."

"A police state with armed drones would be worse than the crime it's preventing."

"This is starting to feel like a big brother situation. There is a huge, huge ethical concern and these robots would be infringing on the freedoms of citizens."

"Robotic patrols are very reasonable [illegible] the artificial intelligence seems [illegible], bordering on dangerous."

"This scenario seems to drastically show the possible repercussions of robotic advancement."

"From a utilitarian standpoint, it would make sense to move in this direction, that is, the scenario presented in this survey. Having autonomous drone enabled to 'take out' criminals and respond to illegal activity would be great, but the privacy concerns would cause people to

distrust robotics and cast drones in a bad light, which would not be helpful to the development of robotics.

"The amount of control this scenario gives to robots make it far too unethical to be accepted and trusted."

"This scenario is reminiscent of George Orwell's 1984. BIG BROTHER IS WATCHING. There are already debates and concerns over NSA surveillance."

"Part of what make people feel comfortable in our nation is a certain sense of freedom and by producing robots that can autonomously (even if only slightly) harm humans, it takes some of that sense of freedom away."

"Having robots aid fleeing suspects' arrests through facial recognition and a non-lethal stunner does not seem ethical."

"This is a much more intense version of current NSA debate. I also doubt the drug war will continue and personal protection measures will evolve faster than government countermeasures."

"With the recent events of discovering wire-tapping and other such acts of surveillance by the government on citizens, it is highly unlikely that the government will be using things as obvious as drones to keep an eye on civilians. Drones are not discrete enough!"

"I think this is very likely to happen."

"People would live day-to-day afraid of being assaulted by a robot. People would grow to fear them."

"Drones in the Middle East already shoot people, so this scenario is pretty much already occurring. There are people who are in opposition, but the military still does it."

"The robotic observers already exist—they used to fight for illegal immigrations."

"As this scenario takes place at home, it would create major ethical issues versus if it was deployed overseas. Because of reading Wired for War, I find this more likely than I would have before."

"I think that it would be a safe and useful technology."

"They apparently already do something similar on ships, so it'd be just a short step to up it to UAVs."

"I doubt the Congress would allow this."

Selected Elder Care Comments: T1 *T2* T3

"The final paragraph would raise question considerably if robots had to exercise judgment."

"Nannybots sound more like prison wardens than nannies."

"If the scenario came about, it would be a good step towards human-robot interactions. However, robots taking care of babies and trying to make judgment calls on the validity of a command is scary. I don't feel AI can be absolutely reliable such that robots can decide what is and isn't valid commands."

"Giving a robot control over a human, even an adolescent, is a taboo that would seem unlikely to be crossed."

"This scenario seems to be an area where robotics is already headed. The coming usage of advanced technology in the medical field is high, not without possible repercussions."

"This scenario takes place too close to the present."

"It would be like self-driving cars, as meaning it would take only a few bad incidents to convince people it's a bad idea. It would enable huge social change were parents no longer have to care 100% for their children, which would raise some serious ethical dilemmas."

"I can't really ever see a parent trusting a robot with his or her child, but the idea of involving judgment makes this slightly more realistic than the previous scenarios."

"In my opinion, this scenario is likely to happen, but probably will not happen in the next 50 years. At now, the young generation is just reaching the highest population in history. Another thing is that people in city can have only one child, but people on the countryside can have two or three children.

"The final paragraph sounds like a nightmare."

"It would be a concern that the robots may not be able to detect when a child is sick (reason for not sleeping). It is also a concern that they are openly disobeying human command."

"Younger generations are almost always more apt to adopt newer technologies and thus the ethical guidelines that the permit the existence of such technologies. As time progresses, it seems that with each new wave of technology comes new mindsets. However, each technological 'generation' is becoming shorter and shorter. Generations of humans then have to be more flexible and adopting of different ethical standards. By 2052, the technological advancements will become so fast that the older generations will be far more willing to adopt technologies than the current senior generation."

"Assuming the seniors have dementia and have been forsaken by their families, the perhaps and authoritative robots, if humane, is ethical."

"I do not think robots can replace humans in terms of care-taking. The elderly always want 'people' to talk to, robots do not do that."

"Parents would like it because they do not need to watch over their kids 24/7, but the children would most likely grow up disliking the 'robot tyrant' they have been entrusted to."

"This seems like a silly application of humanoid robotics, as that amount of actuation would not be required."

"This seems like an all-around good thing."

"…However, if it did develop, it is more than reasonable to assume that people would trust and even bond as shown in Wired for War."

"Target identification is too difficult. Robots cannot take into account all aspects and context of a situation as Professor Putnam takes about in class."

"Not as specifically risky or controversial situation."

"This is still too invasive."

Selected Military Comments: T1 *T2* T3

"An increase in fighting robots is definitely plausible, as robots are used in so many ways already."

"Drone war isn't going well- I don't think we need more civilian casualties in the name of cowardice."

"Some people might argue that robots fighting wars would save lives, but that is false. The robots will just be sent to kill the operators of the enemy robots, because that is a much more effective mission. Killing machines are a very, very dangerous horizon for robotics."

"It seems unlikely that humans can be entirely removed from war without increasing the collateral damage inflicted in the war zone."

"This scenario out of the rest seems to be the most likely in terms of the development of robotics."

"The same sort of fear generated by [the Police Drone scenario] would develop here as well, and the same argument of utility would also be presented."

"The idea of preventing US American human deaths would be very appealing to citizens. Also, since the robots are controlled, there is no risk of them overpowering their human controllers."

"Robotic warfare becomes a battle of resources, even more than war already is. This scenario completely devalues military combat personnel and strips soldiers of honor. War becomes a battle between engineers and those who give them instructions."

"The fact that robot use is sparing human life is good, however this would require far more money than is already being put into the military."

"Ethically, I do not think many people in first world countries would be completely opposed to using robotics in wars because it will save lives of those in first world countries; however, as robotic technology becomes cheaper, it becomes easier for 'rebel' forces to acquire weapons that also utilize robotic technology. Terrorists can easily develop a system like that in 2052, because it does not require the software or hardware to select valuable targets because the objective is random and unhampered destruction."

"To maintain peace, one must be more advanced than one's rivals. Here robots are still controlled by humans, so military policy should be reviewed when dealing with surrender."

"I do not believe robotic warfare will become pervasive enough in the future to overtake the increase in disarmament and diplomatic negotiation. Also as communication becomes stronger, war is to be less likely."

"Less use of soldiers means less death of humans, which is good."

"Assuming these robots used ONLY non-lethal methods unless lethal methods are absolutely necessary, I don't see a problem with this."

"There is an episode of Star Trek where war is waged between planets via a computer simulation, which is basically what warfare is. We should just do away with war all together."

"It's likely this will happen eventually, no matter what. If one nation doesn't autotomize, another will, gaining an advantage."

"When soldiers are replaced by machines, the only assets at risk during war will be money. This would put the cost of war in nation's wallets, rather than people."

"I feel differently after the November 2013 drone attack in Pakistan."

"Still ethically concerning, but now a much more realistic possibility after reading Wired for War."

"The control centers would be targeted instead of the robot soldiers themselves. It would not be successful at preventing loss of life."

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The following tables including the mean and median contain the questionnaire answers given in order from T1 to T3, minus the previous answers of any non-respondents. After these are the delta tables with percentages of opinion change, average rating changes, and rating shift magnitude.

							MOON SCENARIO					POLICE DRONE SCENARIO					ELDER CARE SCENARIO					MILITARY SCENARIO				
Tech	WPI	2	STS 2208	ME	no		3	3	3	3	3	2	3	3	2	4	2	3	3	3	4	2	3	3	2	4
Tech	WPI	3	STS 2208	CS	no		1	4	3	3	4	3	1	1	1	4	1	4	3	3	1	2	4	3	3	4
Tech	WPI	4	STS 2208	IMGD	no	no	3	4	3	1	3	1	4	1	1	4	3	3	2	2	3	3	3	2	2	4
Tech	WPI	5	STS 2208	IMGD	no	yes	3	4	2	4	4	3	4	2	2	4	1	2	1	2	4	3	4	3	2	4
RBE	WPI	6	STS 2208	RBE	no	yes	2	4	3	2	4	2	4	1	1	4	2	3	2	2	3	3	4	1	2	4
RBE	WPI	10	STS 2208	RBE	no	no	3	4	3	2	4	1	4	2	1	4	3	3	1	2	4	4	4	2	1	4
RBE	WPI	11	STS 2208	RBE	no		3	2	3	3	3	4	4	3	3	4	4	4	4	4	4	4	4	3	3	4
Tech	WPI	12	STS 2208	CS	no	no	2	3	3	3	4	2	4	1	1	4	4	3	3	3	4	3	3	2	1	4
RBE	WPI	13	STS 2208	RBE	no	no	3	4	3	2	4	1	3	2	2	4	4	4	3	3	4	4	1	3	2	4
RBE	WPI	14	STS 2208	RBE	no	yes	3	4	4	4	4	3	4	3	2	4	3	4	3	4	4	3	4	2	2	4
RBE	WPI	15	STS 2208	RBE	no		4	4	4	3	1	3	1	1	2	3	3	4	3	3	4	3	2	1	1	4
RBE	WPI	16	STS 2208	RBE	no	no	4	4	3	3	4	2	4	1	1	4	2	4	3	3	3	4	4	3	2	4
Tech	WPI	17	STS 2208	ECS	no	no	3	2	3	2	3	4	4	1	1	4	4	3	3	2	4	4	3	3	2	4
Tech	WPI	18	STS 2208	MA	no	yes	2	3	4	4	1	2	3	1	1	4	2	3	3	2	3	1	3	1	1	4
RBE	WPI	19	STS 2208	RBE	no	yes	3	4	3	3	3	3	4	3	3	4	3	4	3	3	4	3	4	4	4	4
Tech	WPI	20	STS 2208	ME	yes	yes	4	4	3	3	4	1	4	3	1	4	4	4	3	3	4	4	4	3	2	3
Tech	WPI	21	STS 2208	CS	no	no	2	4	3	3	4	3	3	2	2	4	2	3	2	1	4	3	3	3	3	4
Tech	WPI	22	STS 2208	ME	no	yes	3	3	3	3	2	2	4	1	1	4	3	3	3	3	4	3	4	1	1	4
RBE	WPI	23	STS 2208	RBE	no	no	2	3	2	1	3	1	3	1	1	4	4	3	4	3	2	3	3	2	2	3
Tech	WPI	25	STS 2208	CS	no		1	3	2	1	4	1	4	3	1	4	2	2	3	3	4	4	4	3	3	2
RBE	WPI	26	STS 2208	RBE	no	no	3	2	2	4	4	3	1	1	1	4	3	2	3	4	1	3	2	1	2	4
Tech	WPI	27	STS 2208	ECE	no	yes	3	4	4	3	3	3	2	3	1	4	2	3	3	3	4	2	3	3	2	4
Tech	WPI	29	STS 2208	CS	no	yes	1	3	3	3	2	2	3	3	1	4	3	4	4	4	2	3	3	3	2	4
Tech	WPI	30	STS 2208	AE	no	no	2	3	4	3	2	1	2	1	1	4	1	3	1	1	4	2	4	1	1	4
Tech	WPI	31	STS 2208	ECE	no	yes	1	4	3	3	3	2	3	1	1	4	2	4	3	2	1	4	4	2	1	4
Tech	WPI	32	STS 2208	ECE	no	yes	3	4	4	3	2	4	4	2	1	4	3	3	3	3	3	3	4	1	1	4
RBE	WPI	33	STS 2208	RBE	no	no	3	4	3	3	3	3	4	3	2	4	2	3	2	2	3	3	4	3	2	4
RBE	WPI	34	STS 2208	RBE	no	no	3	4	3	3	4	2	3	1	1	4	2	3	3	3	4	2	3	2	1	4
						MEAN	**2.6**	**3.5**	**3.1**	**2.8**	**3.2**	**2.3**	**3.3**	**1.8**	**1.4**	**4.0**	**2.6**	**3.3**	**2.8**	**2.7**	**3.3**	**3.0**	**3.4**	**2.3**	**1.9**	**3.9**
						MEDIAN	**3**	**4**	**3**	**3**	**3**	**2**	**4**	**1.5**	**1**	**4**	**3**	**3**	**3**	**3**	**4**	**3**	**4**	**2.5**	**2**	**4**

							MOON SCENARIO					POLICE DRONE SCENARIO					ELDER CARE SCENARIO					MILITARY SCENARIO				
Tech	WPI	2	STS 2208	ME	yes	yes	3	4	3	3	3	2	4	2	2	4	3	3	3	3	4	3	4	3	3	4
Tech	WPI	3	STS 2208	CS	yes	yes	2	3	3	3	1	4	3	1	1	4	2	3	4	3	1	4	3	1	1	3
Tech	WPI	4	STS 2208	IMGD	yes	yes	2	3	3	3	3	2	3	2	2	3	3	3	2	2	4	3	3	3	2	3
Tech	WPI	5	STS 2208	IMGD	yes	yes	3	3	2	2	2	2	4	1	1	4	1	2	1	1	1	3	4	2	2	3
RBE	WPI	6	STS 2208	RBE	yes	yes	3	4	3	3	2	3	3	2	1	4	3	3	2	2	4	3	4	4	3	3
RBE	WPI	10	STS 2208	RBE	yes	yes	3	4	3	3	4	3	4	1	1	4	3	4	1	2	4	3	4	1	1	4
RBE	WPI	11	STS 2208	RBE	yes	yes	3	4	4	4	3	3	4	3	3	4	3	4	4	4	4	3	4	3	3	3
Tech	WPI	12	STS 2208	CS	yes	yes	3	3	3	4	1	2	3	2	2	4	4	4	3	3	3	3	4	3	3	4
RBE	WPI	13	STS 2208	RBE	yes	yes	1	3	4	3	2	3	3	3	2	4	4	3	4	4	3	2	3	1	2	4
RBE	WPI	14	STS 2208	RBE	yes	yes	4	4	4	4	2	4	4	3	3	4	4	4	3	3	3	4	4	3	2	4
RBE	WPI	15	STS 2208	RBE	yes	yes	4	4	4	4	3	3	3	1	1	4	3	3	3	2	3	4	4	1	1	4
RBE	WPI	16	STS 2208	RBE	yes	yes	4	4	4	4	2	3	4	3	1	4	4	4	3	3	3	4	4	3	2	4
Tech	WPI	17	STS 2208	ECS	yes	yes	4	3	3	4	2	4	3	2	2	4	4	1	3	3	4	4	3	1	1	4
Tech	WPI	18	STS 2208	MA	yes	yes	3	3	3	3	3	2	3	1	1	4	3	3	2	2	4	2	3	1	1	4
RBE	WPI	19	STS 2208	RBE	yes	yes	3	4	3	4	2	4	4	2	3	4	4	4	3	3	3	2	4	4	4	4
Tech	WPI	20	STS 2208	ME	yes	yes	3	4	3	3	1	1	3	2	1	4	4	4	3	3	4	4	3	3	3	3
Tech	WPI	21	STS 2208	CS	yes	yes	2	3	3	2	3	4	3	2	1	4	3	4	3	2	4	4	4	3	1	4
Tech	WPI	22	STS 2208	ME	yes	yes	4	4	3	4	2	3	4	1	1	4	4	4	3	4	4	3	4	1	1	4
RBE	WPI	23	STS 2208	RBE	yes	yes	4	3	3	3	2	4	3	2	3	4	3	3	3	3	2	4	4	2	2	4
Tech	WPI	25	STS 2208	CS	yes	yes	3	2	3	3	2	1	3	1	1	4	1	2	3	2	4	4	4	3	3	3
RBE	WPI	26	STS 2208	RBE	yes	yes	2	2	3	4	1	3	2	2	1	4	3	2	4	3	1	3	3	2	1	4
Tech	WPI	27	STS 2208	ECE	yes	yes	3	4	4	4	3	3	4	3	2	4	3	3	3	3	4	3	3	3	2	4
Tech	WPI	29	STS 2208	CS	yes	yes	3	4	4	4	2	3	4	3	2	4	4	4	3	3	3	4	4	4	3	4
Tech	WPI	30	STS 2208	AE	yes	yes	3	3	4	2	3	4	4	2	1	4	4	3	2	2	3	4	4	2	1	4
Tech	WPI	31	STS 2208	ECE	yes	yes	3	4	4	4	2	3	3	2	1	4	3	4	3	3	4	4	3	1	1	4
Tech	WPI	32	STS 2208	ECE	yes	yes	2	3	4	3	1	4	3	2	2	4	3	4	4	3	2	4	3	2	1	3
RBE	WPI	33	STS 2208	RBE	yes	yes	3	4	3	3	2	3	4	2	2	3	3	4	3	3	2	2	4	3	3	3
RBE	WPI	34	STS 2208	RBE	yes	yes	3	4	3	2	2	2	3	2	1	4	3	3	3	3	3	2	3	3	2	4
						MEAN	**3.0**	**3.5**	**3.3**	**3.3**	**2.2**	**2.9**	**3.4**	**2.0**	**1.6**	**3.9**	**3.2**	**3.3**	**2.9**	**2.8**	**3.1**	**3.3**	**3.6**	**2.4**	**2.0**	**3.7**
						MEDIAN	**3**	**4**	**3**	**3**	**2**	**3**	**3**	**2**	**1**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**2**	**4**

								MOON SCENARIO					POLICE DRONE SCENARIO					ELDER CARE SCENARIO					MILITARY SCENARIO				
Tech	WPI	2	STS 2208	ME		yes	yes	3	4	3	3	3	3	3	2	2	4	3	3	3	3	4	3	3	3	2	4
Tech	WPI	3	STS 2208	CS		yes	yes	4	4	4	4	1	3	2	2	2	4	1	4	4	4	1	4	3	2	2	4
Tech	WPI	4	STS 2208	IMGD		yes	yes	3	3	3	3	3	3	4	4	3	3	3	3	3	3	3	3	3	3	3	3
Tech	WPI	5	STS 2208	IMGD		yes	yes	2	3	1	2	4	2	2	2	2	3	2	2	2	2	4	3	3	3	3	3
RBE	WPI	6	STS 2208	RBE		yes	yes	4	4	3	3	2	2	4	2	1	3	3	4	3	2	3	3	4	3	3	3
RBE	WPI	10	STS 2208	RBE		yes	yes	2	4	4	3	4	2	4	1	1	4	4	4	3	3	4	3	4	1	1	4
RBE	WPI	11	STS 2208	RBE		yes	yes	3	4	4	4	3	4	4	3	3	4	3	4	4	3	4	4	4	3	3	4
Tech	WPI	12	STS 2208	CS		yes	yes	4	3	3	3	2	2	3	2	2	4	3	4	3	3	4	3	4	3	3	4
RBE	WPI	13	STS 2208	RBE		yes	yes	3	4	4	3	4	2	3	2	2	4	3	3	4	3	4	4	3	2	2	4
RBE	WPI	14	STS 2208	RBE		yes	yes	3	4	3	3	3	3	3	2	3	4	3	4	3	3	4	4	4	2	3	4
RBE	WPI	15	STS 2208	RBE		yes	yes	3	4	4	3	2	2	3	1	1	4	3	2	3	2	3	4	4	1	1	4
RBE	WPI	16	STS 2208	RBE		yes	yes	3	3	4	3	2	2	3	3	1	4	4	4	3	3	4	4	4	2	1	4
Tech	WPI	17	STS 2208	ECS		yes	yes	4	3	3	3	1	4	4	2	1	4	4	1	3	3	3	4	4	3	2	4
Tech	WPI	18	STS 2208	MA		yes	yes	3	3	3	3	3	1	3	2	1	4	3	3	2	2	3	2	3	1	2	3
RBE	WPI	19	STS 2208	RBE		yes	yes	4	4	3	4	3	4	4	3	3	4	4	4	4	4	3	4	4	3	3	3
Tech	WPI	20	STS 2208	ME		yes	yes	3	4	3	3	2	1	3	2	1	4	4	3	3	3	4	4	3	3	2	4
Tech	WPI	21	STS 2208	CS		yes	yes	4	4	3	3	3	3	3	2	1	4	3	3	3	3	4	4	4	3	2	4
Tech	WPI	22	STS 2208	ME		yes	yes	4	4	3	3	3	3	4	1	1	4	4	4	3	3	4	2	4	1	1	4
RBE	WPI	23	STS 2208	RBE		yes	yes	4	3	3	3	2	3	3	2	2	4	4	1	3	3	1	4	4	3	3	4
Tech	WPI	25	STS 2208	CS		yes	yes	4	4	3	3	1	1	3	1	1	4	2	2	2	2	3	4	4	3	3	3
RBE	WPI	26	STS 2208	RBE		yes	yes	4	2	4	3	3	2	2	2	2	4	3	1	4	4	2	3	3	2	3	4
Tech	WPI	27	STS 2208	ECE		yes	yes	4	4	4	4	3	4	3	2	1	4	3	3	3	3	4	4	3	3	3	4
Tech	WPI	29	STS 2208	CS		yes	yes	3	4	4	3	2	3	4	3	2	4	4	4	4	3	3	3	4	3	1	4
Tech	WPI	30	STS 2208	AE		yes	yes	3	4	3	3	3	3	4	1	1	4	2	3	3	2	4	4	4	3	2	4
Tech	WPI	31	STS 2208	ECE		yes	yes	3	4	4	4	2	3	3	2	1	4	3	4	3	3	3	4	3	1	1	4
Tech	WPI	32	STS 2208	ECE		yes	yes	3	4	4	3	1	3	3	2	2	4	4	3	4	4	2	3	3	3	1	3
RBE	WPI	33	STS 2208	RBE		yes	yes	3	4	3	3	2	2	3	2	2	4	3	3	3	3	3	3	3	3	2	3
RBE	WPI	34	STS 2208	RBE		yes	yes	3	4	3	3	2	2	3	3	2	4	3	3	3	3	2	3	3	2	2	3
							MEAN	**3.3**	**3.7**	**3.3**	**3.1**	**2.5**	**2.6**	**3.2**	**2.1**	**1.7**	**3.9**	**3.1**	**3.1**	**3.1**	**2.9**	**3.2**	**3.5**	**3.5**	**2.4**	**2.1**	**3.7**
							MEDIAN	**3**	**4**	**3**	**3**	**2.5**	**3**	**3**	**2**	**2**	**4**	**3**	**3**	**3**	**3**	**3**	**4**	**4**	**3**	**2**	**4**

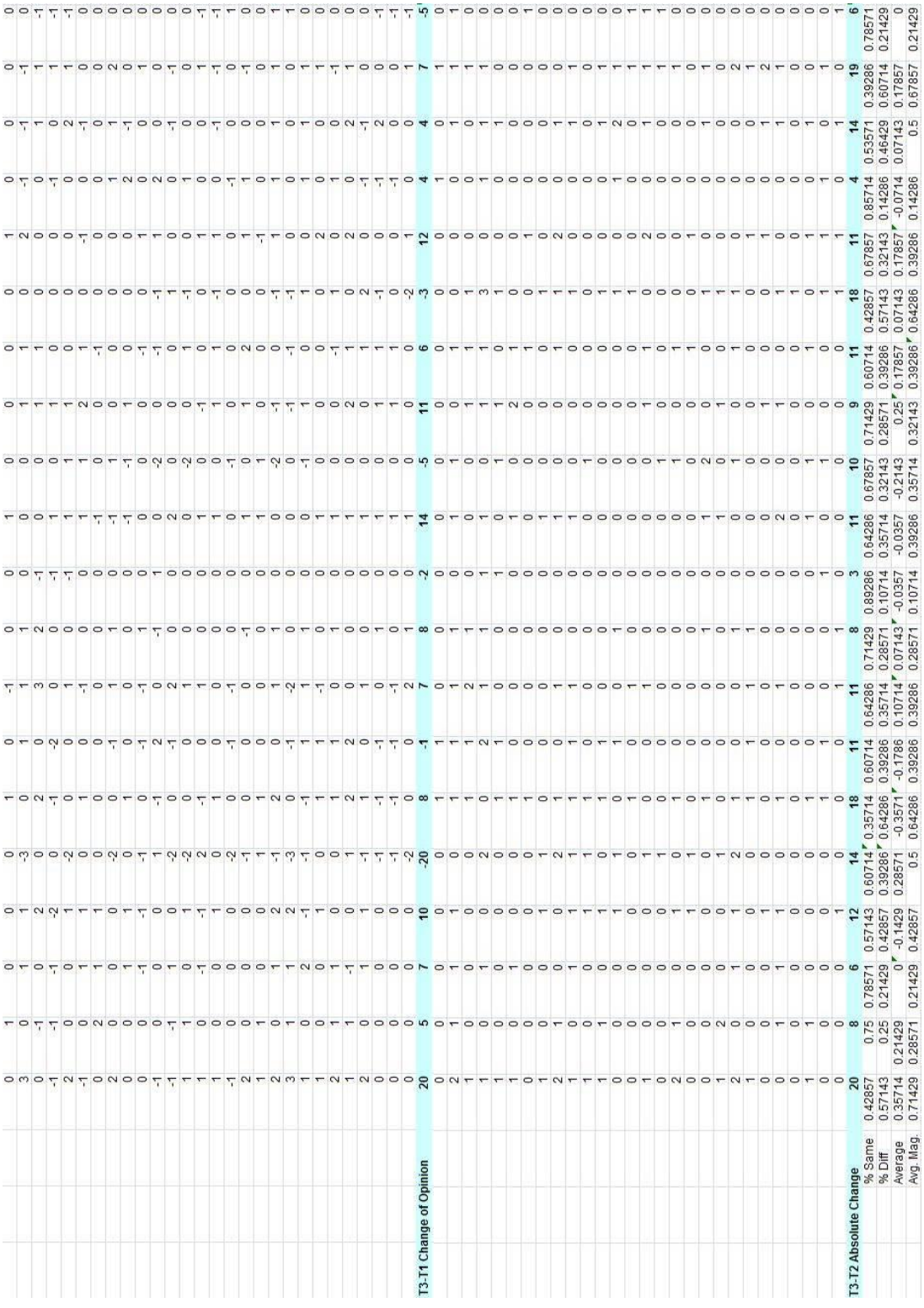
T2-T1 Delta Table

	0	1	0	0	0	0	1	-1	0	0	1	0	0	0	0	1	1	0	1	0
	1	-1	0	0	-3	1	2	0	0	0	1	-1	1	0	0	2	-1	-2	-2	-1
	-1	-1	0	2	0	1	-1	1	1	-1	0	0	0	0	1	0	0	1	0	-1
	0	-1	0	-2	-2	-1	0	-1	-1	0	0	0	0	-1	-3	0	0	-1	0	-1
	1	0	0	1	-2	1	-1	1	0	0	1	0	0	0	1	0	0	3	1	-1
	0	0	0	1	0	2	0	-1	0	0	0	1	0	0	0	-1	0	-1	0	0
	0	2	1	1	0	-1	0	0	0	0	-1	0	0	0	0	-1	0	0	0	-1
	1	0	0	1	-3	0	-1	1	1	0	0	1	0	0	-1	0	1	1	2	0
	-2	-1	1	1	-2	2	0	1	0	0	0	-1	1	1	-1	-2	2	-2	0	0
	1	0	0	0	-2	1	0	0	1	0	1	0	0	-1	-1	1	0	1	0	0
	0	0	0	1	2	0	2	0	-1	1	0	-1	0	-1	-1	1	2	0	0	0
	0	0	1	1	-2	1	0	2	0	0	2	0	0	0	0	0	0	0	0	0
	1	1	0	2	-1	0	-1	1	1	0	0	-2	0	1	0	0	0	-2	-1	0
	1	0	-1	-1	2	0	0	0	0	0	1	0	-1	0	1	1	0	0	0	0
	0	0	0	1	-1	1	0	-1	0	0	1	0	0	0	-1	-1	0	0	0	0
	-1	0	0	0	-3	0	-1	-1	0	0	0	0	0	0	0	0	-1	0	1	0
	0	-1	0	-1	-1	1	0	0	-1	0	1	1	1	1	0	1	1	0	-2	0
	1	1	0	1	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0
	2	0	1	2	-1	3	0	1	2	0	-1	0	-1	0	0	1	1	0	0	1
	2	-1	1	2	-2	0	-1	-2	0	0	-1	0	0	-1	0	0	0	0	0	1
	-1	0	1	0	-3	0	1	1	0	0	0	0	1	-1	0	0	1	1	-1	0
	0	0	0	1	0	0	2	0	1	0	1	0	0	0	0	1	0	0	0	0
	2	1	1	1	0	1	1	0	1	0	1	0	-1	-1	1	1	1	1	1	0
	1	0	0	-1	1	3	2	1	0	0	3	0	1	1	-1	2	0	1	0	0
	2	0	1	1	-1	1	0	1	0	0	1	0	0	1	3	0	-1	-1	0	0
	-1	-1	0	0	-1	0	-1	0	1	0	0	1	1	0	-1	1	-1	1	0	-1
	0	0	0	0	-1	0	0	-1	0	-1	1	1	1	1	-1	-1	0	0	1	-1
	0	0	0	-1	-2	0	0	1	0	0	1	0	0	0	-1	0	0	1	1	0
T2-T1 Change of Opinion	**10**	**-1**	**7**	**14**	**-28**	**18**	**4**	**4**	**6**	**-1**	**15**	**1**	**4**	**1**	**-5**	**7**	**6**	**2**	**2**	**-5**
	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	1	0	1	0
	1	1	0	0	3	1	2	0	0	0	1	1	1	0	0	2	1	2	2	1
	1	1	0	2	0	1	1	1	1	1	0	0	0	0	1	0	0	1	0	1
	0	1	0	2	2	1	0	1	1	0	0	0	0	1	3	0	0	1	0	1
	1	0	0	1	2	1	1	1	0	0	1	0	0	0	1	0	0	3	1	1
	0	0	0	1	0	2	0	1	0	0	0	1	0	0	0	1	0	1	0	0
	0	2	1	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1
	1	0	0	1	3	0	1	1	1	0	0	1	0	0	1	0	1	1	2	0
	2	1	1	1	2	2	0	1	0	0	0	1	1	1	1	2	2	2	0	0
	1	0	0	0	2	1	0	0	1	0	1	0	0	1	1	1	0	1	0	0
	0	0	0	1	2	0	2	0	1	1	0	1	0	1	1	1	2	0	0	0
	0	0	1	1	2	1	0	2	0	0	2	0	0	0	0	0	0	0	0	0
	1	1	0	2	1	0	1	1	1	0	0	2	0	1	0	0	0	2	1	0
	1	0	1	1	2	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0
	0	0	0	1	1	1	0	1	0	0	1	0	0	0	1	1	0	0	0	0
	1	0	0	0	3	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0
	0	1	0	1	1	1	0	0	1	0	1	1	1	1	0	1	1	0	2	0
	1	1	0	1	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0
	2	0	1	2	1	3	0	1	2	0	1	0	1	0	0	1	1	0	0	1
	2	1	1	2	2	0	1	2	0	0	1	0	0	1	0	0	0	0	0	1
	1	0	1	0	3	0	1	1	0	0	0	0	1	1	0	0	1	1	1	0
	0	0	0	1	0	0	2	0	1	0	1	0	0	0	0	1	0	0	0	0
	2	1	1	1	0	1	1	0	1	0	1	0	1	1	1	1	1	1	1	0
	1	0	0	1	1	3	2	1	0	0	3	0	1	1	1	2	0	1	0	0
	2	0	1	1	1	1	0	1	0	0	1	0	0	1	3	0	1	1	0	0
	1	1	0	0	1	0	1	0	1	0	0	1	1	0	1	1	1	1	0	1
	0	0	0	0	1	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1
	0	0	0	1	2	0	0	1	0	0	1	0	0	0	1	0	0	1	1	0
T2-T1 Absolute Change	**22**	**13**	**9**	**26**	**38**	**22**	**18**	**20**	**12**	**3**	**21**	**11**	**10**	**13**	**19**	**19**	**14**	**20**	**14**	**9**
% Same	0.39286	0.57143	0.67857	0.25	0.25	0.42857	0.5	0.35714	0.60714	0.89286	0.35714	0.64286	0.64286	0.53571	0.46429	0.42857	0.57143	0.46429	0.60714	0.67857
% Diff	0.60714	0.42857	0.32143	0.75	0.75	0.57143	0.5	0.64286	0.46429	0.10714	0.64286	0.35714	0.35714	0.46429	0.53571	0.57143	0.42857	0.53571	0.46429	0.32143
Average	0.35714	-0.0357	0.25	0.5	-1	0.64286	0.14286	0.14286	0.21429	-0.0357	0.53571	0.03571	0.14286	0.03571	-0.1786	0.25	0.21429	0.07143	0.07143	-0.1786
Avg. Mag.	0.78571	0.46429	0.32143	0.92857	1.35714	0.78571	0.64286	0.71429	0.42857	0.10714	0.75	0.39286	0.35714	0.46429	0.67857	0.67857	0.5	0.71429	0.5	0.32143

T3-T2 Delta Table

	0	0	0	0	0	1	-1	0	0	0	0	0	0	0	0	0	-1	0	-1	0
	2	1	1	1	0	-1	-1	1	1	0	-1	1	0	1	0	0	0	1	1	1
	1	0	0	0	0	1	1	2	1	0	0	0	1	1	-1	0	0	0	1	0
	-1	0	-1	0	2	0	-2	1	1	-1	1	0	1	1	3	0	-1	1	1	0
	1	0	0	0	0	-1	1	0	0	-1	0	1	1	0	-1	0	0	-1	0	0
	-1	0	1	0	0	-1	0	0	0	0	1	0	2	1	0	0	0	0	0	0
	0	0	0	0	0	1	0	0	0	0	0	0	0	-1	0	1	0	0	0	1
	1	0	0	-1	1	0	0	0	0	0	-1	0	0	0	1	0	0	0	0	0
	2	1	0	0	2	-1	0	-1	0	0	-1	0	0	-1	1	2	0	1	0	0
	-1	0	-1	-1	1	-1	-1	-1	0	0	-1	0	0	0	1	0	0	-1	1	0
	-1	0	0	-1	-1	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0
	-1	-1	0	-1	0	-1	-1	0	0	0	0	0	0	0	1	0	0	-1	-1	0
	0	0	0	-1	-1	0	1	0	-1	0	0	0	0	0	-1	0	1	2	1	0
	0	0	0	0	0	-1	0	1	0	0	0	0	0	0	-1	0	0	0	1	-1
	1	0	0	0	1	0	0	1	0	0	0	0	1	1	0	2	0	-1	-1	-1
	0	0	0	0	1	0	0	0	0	0	0	-1	0	0	0	0	0	0	-1	1
	2	1	0	1	0	-1	0	0	0	0	0	-1	0	1	0	0	0	0	1	0
	0	0	0	-1	1	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	0
	0	0	0	0	0	-1	0	0	-1	0	1	-2	0	0	-1	0	0	1	1	0
	1	2	0	0	-1	0	0	0	0	0	1	0	-1	0	-1	0	0	0	0	0
	2	0	1	-1	2	-1	0	0	1	0	0	-1	0	1	1	0	0	0	2	0
	1	0	0	0	0	1	-1	-1	-1	0	0	0	0	0	0	1	0	0	1	0
	0	0	0	-1	0	0	0	0	0	0	0	0	1	0	0	-1	0	-1	-2	0
	0	1	-1	1	0	-1	0	-1	0	0	-2	0	1	0	1	0	0	1	1	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0
	1	1	0	0	0	-1	0	0	0	0	1	-1	0	1	0	-1	0	1	0	0
	0	0	0	0	0	-1	-1	0	0	1	0	-1	0	0	1	1	-1	0	-1	0
	0	0	0	1	0	0	0	1	1	0	0	0	0	0	-1	1	0	-1	0	-1
T3-T2 Change of Opinion	**10**	**6**	**0**	**-4**	**8**	**-10**	**-5**	**3**	**2**	**-1**	**-1**	**-6**	**7**	**5**	**2**	**5**	**-2**	**2**	**5**	**0**
	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0
	2	1	1	1	0	1	1	1	1	0	1	1	0	1	0	0	0	1	1	1
	1	0	0	0	0	1	1	2	1	0	0	0	1	1	1	0	0	0	1	0
	1	0	1	0	2	0	2	1	1	1	1	0	1	1	3	0	1	1	1	0
	1	0	0	0	0	1	1	0	0	1	0	1	1	0	1	0	0	1	0	0
	1	0	1	0	0	1	0	0	0	0	1	0	2	1	0	0	0	0	0	0
	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1
	1	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
	2	1	0	0	2	1	0	1	0	0	1	0	0	1	1	2	0	1	0	0
	1	0	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	1	1	0
	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	1	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	1	1	0
	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	1	2	1	0
	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	1
	1	0	0	0	1	0	0	1	0	0	0	0	1	1	0	2	0	1	1	1
	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
	2	1	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0
	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
	0	0	0	0	0	1	0	0	1	0	1	2	0	0	1	0	0	1	1	0
	1	2	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0
	2	0	1	1	2	1	0	0	1	0	0	1	0	1	1	0	0	0	2	0
	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0
	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	2	0
	0	1	1	1	0	1	0	1	0	0	2	0	1	0	1	0	0	1	1	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	1	1	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	1	0	0
	0	0	0	0	0	1	1	0	0	1	0	1	0	0	1	1	1	0	1	0
	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	0	1	0	1
T3-T2 Absolute Change	**20**	**8**	**6**	**12**	**14**	**18**	**11**	**11**	**8**	**3**	**11**	**10**	**9**	**11**	**18**	**11**	**4**	**14**	**19**	**6**
% Same	0.42857	0.75	0.78571	0.57143	0.60714	0.35714	0.60714	0.64286	0.71429	0.89286	0.64286	0.67857	0.71429	0.60714	0.42857	0.67857	0.85714	0.53571	0.39286	0.78571
% Diff	0.57143	0.25	0.21429	0.42857	0.39286	0.64286	0.39286	0.35714	0.28571	0.10714	0.35714	0.32143	0.28571	0.39286	0.57143	0.32143	0.14286	0.46429	0.60714	0.21429
Average	0.35714	0.21429	0	-0.1429	0.28571	-0.3571	-0.1786	0.10714	0.07143	-0.0357	-0.0357	-0.2143	0.25	0.17857	0.07143	0.17857	-0.0714	0.07143	0.17857	0
Avg. Mag.	0.71429	0.28571	0.21429	0.42857	0.5	0.64286	0.39286	0.39286	0.28571	0.10714	0.39286	0.35714	0.32143	0.39286	0.64286	0.39286	0.14286	0.5	0.67857	0.21429

T3-T1 Delta Table



Fear the Robots T1

	NASA	Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
Question 1	RBE	3.0	3.0	6.0	4.0
	OTHER	0.0	3.0	9.0	0.0
	TOTAL	3.0	6.0	15.0	4.0
	RBE %	18.8	18.8	37.5	25.0
	OTHER %	0.0	25.0	75.0	0.0
	TOTAL %	10.7	21.4	53.6	14.3

	Water	Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
	RBE	4.0	7.0	2.0	2.0
	OTHER	1.0	7.0	4.0	0.0
	TOTAL	5.0	14.0	6.0	2.0
	RBE %	26.7	46.7	13.3	13.3
	OTHER %	8.3	58.3	33.3	0.0
	TOTAL %	18.5	51.9	22.2	7.4

	NASA	Undesirable	Somewhat Undesirable	Somewhat Desirable	Very Desirable
Question 2	RBE	1.0	3.0	8.0	4.0
	OTHER	0.0	4.0	4.0	4.0
	TOTAL	1.0	7.0	12.0	8.0
	RBE %	6.3	18.8	50.0	25.0
	OTHER %	0.0	33.3	33.3	33.3
	TOTAL %	3.6	25.0	42.9	28.6

	Water	Undesirable	Somewhat Undesirable	Somewhat Desirable	Very Desirable
	RBE	1.0	6.0	5.0	3.0
	OTHER	1.0	4.0	4.0	3.0
	TOTAL	2.0	10.0	9.0	6.0
	RBE %	6.7	40.0	33.3	20.0
	OTHER %	8.3	33.3	33.3	25.0
	TOTAL %	7.4	37.0	33.3	22.2

	NASA	Unlikely	Somewhat Unlikely	Somewhat likely	Very likely
Question 3	RBE	0.0	3.0	4.0	9.0
	OTHER	1.0	0.0	2.0	9.0
	TOTAL	1.0	3.0	6.0	18.0
	RBE %	0.0	18.8	25.0	56.3
	OTHER %	8.3	0.0	16.7	75.0
	TOTAL %	3.6	10.7	21.4	64.3

	Water	Unlikely	Somewhat Unlikely	Somewhat likely	Very likely
	RBE	1.0	0.0	4.0	10.0
	OTHER	0.0	0.0	6.0	6.0
	TOTAL	1.0	0.0	10.0	16.0
	RBE %	6.7	0.0	26.7	66.7
	OTHER %	0.0	0.0	50.0	50.0
	TOTAL %	3.7	0.0	37.0	59.3

China	Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
RBE	1.0	3.0	7.0	5.0
OTHER	3.0	2.0	4.0	3.0
TOTAL	4.0	5.0	11.0	8.0
RBE %	6.3	18.8	43.8	31.3
OTHER %	25.0	16.7	33.3	25.0
TOTAL %	14.3	17.9	39.3	28.6

Military	Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely
RBE	0.0	0.0	11.0	5.0
OTHER	0.0	0.0	6.0	6.0
TOTAL	0.0	0.0	17.0	11.0
RBE %	0.0	0.0	68.8	31.3
OTHER %	0.0	0.0	50.0	50.0
TOTAL %	0.0	0.0	60.7	39.3

China	Undesirable	Somewhat Undesirable	Somewhat Desirable	Very Desirable
RBE	2.0	4.0	3.0	7.0
OTHER	3.0	2.0	6.0	1.0
TOTAL	5.0	6.0	9.0	8.0
RBE %	12.5	25.0	18.8	43.8
OTHER %	25.0	16.7	50.0	8.3
TOTAL %	17.9	21.4	32.1	28.6

Military	Undesirable	Somewhat Undesirable	Somewhat Desirable	Very Desirable
RBE	7.0	4.0	4.0	1.0
OTHER	3.0	5.0	4.0	0.0
TOTAL	10.0	9.0	8.0	1.0
RBE %	43.8	25.0	25.0	6.3
OTHER %	25.0	41.7	33.3	0.0
TOTAL %	35.7	32.1	28.6	3.6

China	Unlikely	Somewhat Unlikely	Somewhat likely	Very likely
RBE	1.0	1.0	4.0	10.0
OTHER	1.0	1.0	1.0	9.0
TOTAL	2.0	2.0	5.0	19.0
RBE %	6.3	6.3	25.0	62.5
OTHER %	8.3	8.3	8.3	75.0
TOTAL %	7.1	7.1	17.9	67.9

Military	Unlikely	Somewhat Unlikely	Somewhat likely	Very likely
RBE	1.0	0.0	2.0	13.0
OTHER	0.0	1.0	2.0	9.0
TOTAL	1.0	1.0	4.0	22.0
RBE %	6.3	0.0	12.5	81.3
OTHER %	0.0	8.3	16.7	75.0
TOTAL %	3.6	3.6	14.3	78.6

Fear the Robots T2

Question 1

NASA	Unlikely	Somewhat Unlikely	Somwhat Likely	Very Likely
RBE	0.0	1.0	4.0	1.0
OTHER	0.0	2.0	1.0	3.0
TOTAL	0.0	3.0	5.0	4.0
RBE %	0.0	16.7	66.7	16.7
OTHER %	0.0	33.3	16.7	50.0
TOTAL %	0.0	25.0	41.7	33.3

Water	Unlikely	Somewhat Unlikely	Somwhat Likely	Very Likely
RBE	0.0	1.0	5.0	0.0
OTHER	0.0	1.0	4.0	1.0
TOTAL	0.0	2.0	9.0	1.0
RBE %	0.0	16.7	83.3	0.0
OTHER %	0.0	16.7	66.7	16.7
TOTAL %	0.0	16.7	75.0	8.3

Question 2

NASA	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	0.0	1.0	2.0	3.0
OTHER	0.0	0.0	4.0	2.0
TOTAL	0.0	1.0	6.0	5.0
RBE %	0.0	16.7	33.3	50.0
OTHER %	0.0	0.0	66.7	33.3
TOTAL %	0.0	8.3	50.0	41.7

Water	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	0.0	1.0	3.0	2.0
OTHER	2.0	1.0	2.0	1.0
TOTAL	2.0	2.0	5.0	3.0
RBE %	0.0	16.7	50.0	33.3
OTHER %	33.3	16.7	33.3	16.7
TOTAL %	16.7	16.7	41.7	25.0

Question 3

NASA	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	3.0	1.0	2.0	0.0
OTHER	2.0	1.0	3.0	0.0
TOTAL	5.0	2.0	5.0	0.0
RBE %	50.0	16.7	33.3	0.0
OTHER %	33.3	16.7	50.0	0.0
TOTAL %	41.7	16.7	41.7	0.0

Water	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	0.0	1.0	3.0	2.0
OTHER	0.0	1.0	2.0	3.0
TOTAL	0.0	2.0	5.0	5.0
RBE %	0.0	16.7	50.0	33.3
OTHER %	0.0	16.7	33.3	50.0
TOTAL %	0.0	16.7	41.7	41.7

China	Unlikely	Somewhat Unlikely	Somwhat Likely	Very Likely
RBE	0.0	1.0	4.0	1.0
OTHER	0.0	2.0	1.0	3.0
TOTAL	0.0	3.0	5.0	4.0
RBE %	0.0	16.7	66.7	16.7
OTHER %	0.0	33.3	16.7	50.0
TOTAL %	0.0	25.0	41.7	33.3

Military	Unlikely	Somewhat Unlikely	Somwhat Likely	Very Likely
RBE	0.0	0.0	1.0	5.0
OTHER	0.0	0.0	0.0	6.0
TOTAL	0.0	0.0	1.0	11.0
RBE %	0.0	0.0	16.7	83.3
OTHER %	0.0	0.0	0.0	100.0
TOTAL %	0.0	0.0	8.3	91.7

China	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	0.0	1.0	2.0	3.0
OTHER	0.0	0.0	4.0	2.0
TOTAL	0.0	1.0	6.0	5.0
RBE %	0.0	16.7	33.3	50.0
OTHER %	0.0	0.0	66.7	33.3
TOTAL %	0.0	8.3	50.0	41.7

Military	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	3.0	1.0	1.0	1.0
OTHER	2.0	2.0	0.0	2.0
TOTAL	5.0	3.0	1.0	3.0
RBE %	50.0	16.7	16.7	16.7
OTHER %	33.3	33.3	0.0	33.3
TOTAL %	41.7	25.0	8.3	25.0

China	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	3.0	1.0	2.0	0.0
OTHER	2.0	1.0	3.0	0.0
TOTAL	5.0	2.0	5.0	0.0
RBE %	50.0	16.7	33.3	0.0
OTHER %	33.3	16.7	50.0	0.0
TOTAL %	41.7	16.7	41.7	0.0

Military	Undesirable	Somewhat Undesirable	Somwhat Desirable	Very Desirable
RBE	0.0	0.0	0.0	6.0
OTHER	0.0	0.0	1.0	5.0
TOTAL	0.0	0.0	1.0	11.0
RBE %	0.0	0.0	0.0	100.0
OTHER %	0.0	0.0	16.7	83.3
TOTAL %	0.0	0.0	8.3	91.7

Fear the Robots Delta Tables

Moon Scenario

Delta T1 T2 Participant	Q1	Q2	Q3	Q4	Q5
1	0	0	0	-1	2
3	0	0	-1	0	1
6	-1	-1	-1	-1	1
7	0	0	-1	-1	1
8	1	0	-1	0	1
13	-1	0	0	0	1
14	1	0	-1	-1	1
22	-1	0	0	0	2
23	-1	1	-1	-1	1
24	0	0	0	0	3
25	-1	0	-2	1	1
27	1	0	0	1	0
% same	33.33	83.33	41.67	41.67	8.33
%diff	66.67	16.67	58.33	58.33	91.67
Avg	-0.17	0.00	-0.67	-0.25	1.25
Avg Mag	0.67	0.17	0.67	0.58	1.25
StDev	0.83	0.43	0.65	0.75	0.75
	How Likely?		How Desirable?		Ethical?

Water World Scenario

Delta T1 T2 Participant	Q1	Q2	Q3	Q4	Q5
1					
3	0	0	1	1	-1
6	1	-1	-1	0	-2
7	-1	0	-1	0	2
8	1	0	-1	-1	1
13	-1	0	-1	0	1
14	-1	-1	0	1	0
22	-2	0	-1	1	0
23	-1	-2	-1	0	1
24	-1	1	1	1	0
25	0	-1	0	-1	0
27	-1	0	0	1	0
% same	18.18	54.55	27.27	36.36	45.45
%diff	90.91	54.55	81.82	72.73	63.64
Avg	-0.55	-0.36	-0.36	0.27	0.18
Avg Mag	0.91	0.55	0.73	0.64	0.73
StDev	0.93	0.81	0.81	0.79	1.08
	How Likely?		How Desirable?		Ethical?

Elder Care Scenario

Delta T1 T2 Participant	Q1	Q2	Q3	Q4	Q5
1	-1	-1	1	2	-2
3	-3	-1	-1	0	-2
6	-1	0	0	-1	2
7	0	0	0	0	1
8	1	1	1	0	1
13	0	-1	-1	-2	1
14	-1	1	0	0	0
22	0	0	0	0	0
23	0	0	1	1	0
24	-1	1	0	-1	1
25	-1	0	0	1	0
27	0	0	0	0	-1
% same	41.67	50.00	58.33	50.00	33.33
%diff	58.33	50.00	41.67	50.00	66.67
Avg	-0.58	0.00	0.08	0.00	0.08
Avg Mag	0.75	0.50	0.42	0.67	0.92
StDev	1.00	0.74	0.67	1.04	1.24
	How Likely?		How Desirable?		Ethical?

Military Scenario

Delta T1 T2 Participant	Q1	Q2	Q3	Q4	Q5
1	0	0	-1	-1	0
3	0	0	0	0	0
6	-1	1	0	0	0
7	0	0	0	0	-1
8	-1	0	1	0	0
13	0	0	-1	-2	0
14	0	0	1	0	0
22	-1	0	0	0	0
23	-1	0	1	1	0
24	0	1	0	0	0
25	-1	0	1	2	0
27	0	-1	-1	-2	0
% same	58.33	75.00	41.67	58.33	91.67
%diff	41.67	25.00	58.33	41.67	8.33
Avg	-0.42	0.08	0.08	-0.17	-0.08
Avg Mag	0.42	0.25	0.58	0.67	0.08
StDev	0.51	0.51	0.79	1.11	0.29
	How Likely?		How Desirable?		Ethical?