

# Lethality and Autonomous Systems: Survey Design and Results\*

Lilia Moshkina  
Ronald C. Arkin  
Mobile Robot Laboratory  
College of Computing  
Georgia Institute of Technology  
{lilia,arkin}@cc.gatech.edu

## Abstract

*This article reports the methods and results of an on-line survey addressing the issues surrounding lethality and autonomous systems that was conducted as part of a research project for the U.S. Army Research Office. The data from this survey were analyzed both qualitatively, providing a comparison between four different demographic samples targeted in the survey (namely, robotics researchers, policymakers, the military, and the general public), and quantitatively, for the robotics researcher demographic. In addition to the analysis, the design and administration of this survey and a discussion of the survey results are provided.*

## 1. INTRODUCTION

Battlefield robotic systems are appearing at an ever increasing rate. There are already weaponized unmanned systems deployed or being deployed in Afghanistan and Iraq [1,2], the Israeli-Palestinian Border [3], and the Korean Demilitarized Zone [4]. There is also likelihood of an increasing role of autonomy for these battlefield robots as humans are gradually moved further and further out of the loop [5,6].

The Georgia Tech Mobile Robot Laboratory is conducting a research effort under funding from the U.S. Army Research Office entitled “An Ethical Basis for Autonomous System Deployment”. It is concerned with two research thrusts addressing the issues of autonomous robots capable of lethality:

- 1) What is acceptable? *Can we understand, define, and shape expectations regarding battlefield robotics?* Toward that end, a survey has been conducted to establish opinion on the use of lethality by autonomous systems spanning the public, researchers, policymakers, and military personnel to ascertain the current point-of-view maintained by various demographic groups on this subject.
- 2) What can be done? *Artificial Conscience* We are designing a computational implementation of an ethical code within an existing autonomous robotic system, i.e., an “artificial conscience”, that will be able to govern an autonomous system’s behavior in a manner consistent with the rules of war.

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This article presents the results obtained for (1) above that reflect the opinions of a variety of demographics worldwide. Results for (2) are reported separately in [5]. In Section 2 of this report, the design and administration of the survey instrument is presented, followed in Sections 3-5 with an analysis and discussion of the results obtained. Section 6 concludes the report.

## **2. SURVEY DESIGN**

### *2.1 SURVEY OBJECTIVES AND STRUCTURE*

An online public opinion survey on the use of robots capable of lethal force in warfare has been completed. The main objective of the survey was to determine the level of acceptance by various demographics, including the general public, robotics researchers, policymakers, and the military, of the employment of potentially lethal robots in warfare, as well as their attitude towards related ethical issues.

This survey can be described as descriptive-explanatory [7], where in addition to presenting a more general picture of the public view on the matter, we look at the relationships between a number of variables. In particular, we focus on the relationships described below.

First, we assess whether the source of authority over the entity employed in warfare has an effect on the level of acceptance. We compare three different entities: a human soldier, a robot serving as an extension of a human soldier, and an autonomous robot. The main distinction in the latter two categories lies in the source of control over the robot's actions: a human soldier is in control of the robot in the case of "robot as extension", and in the case of "autonomous robot", the robot itself is in control over its decisions, including those regarding the use of lethal force. This independent variable is referred to as the "level of autonomy".

Second, we seek to identify whether membership in one of the following demographics communities: robotics researchers, policymakers, military or general public, affects opinion on the use of lethal robots. The membership in these communities is determined by participants' self-identifying themselves as having had experience in any of the first three categories, and with the general public comprising those who have not. This independent variable is referred to as "community type".

Finally, we look at whether a variety of other demographic factors, such as cultural background, education level, overall attitude towards robotics and technology in general, etc., play a role in how people view this issue.

### *2.2 SURVEY STRUCTURE*

All of the elements of the survey: each question, survey structure and layout, were designed in accordance with survey design guidelines presented in [8], and then adapted for internet use, following the recommendations in [8] and [9]. The survey was organized into three parts: 1) a short introductory section on prior knowledge of and attitude towards military robots and their use for lethal actions; 2) the main section, exploring the terms of acceptance and ethical issues; and 3) a demographics section. Screenshots of the entire survey as it was deployed online are presented in Appendix A.

The first section is presented to the participants immediately after the consent form and before the formal definitions are provided for the terms robot, a robot as an extension of a human soldier, and an autonomous robot. This is designed to assess any prior knowledge people may have of robots in general and in the military, as well as their overall attitude towards employing human soldiers and robots in warfare in a lethal capacity.

The main (second) section was presented after these definitions; for clarity, they are shown in Figure 1. The questions in this section, where appropriate, were asked separately for each level of autonomy: human soldier, robot as an extension of human soldier, and autonomous robot. They were of the following types:

- 1) Given that military robots follow the same laws of war and code of conduct as for a human soldier, in which roles and situations is the use of such robots acceptable?
- 2) What does it mean to behave ethically in warfare?
- 3) Should robots be able to refuse an order from a human, and what ethical standards should they be held to?
- 4) Who, and to what extent, is responsible for any lethal errors made?
- 5) What are the benefits and concerns for use of such robots?
- 6) Would an emotional component be beneficial to a military robot?

For the rest of the survey, we will be using some terms that should be defined the same for everyone. Please look through them and try to think of them whenever we use them in the questions. They will be repeated at the top of each page for your convenience. These terms are:

- Robot: as defined for this survey, an automated machine or vehicle, capable of independent perception, reasoning, and action
- Robot acting as an extension of a human soldier: a robot under the direct authority of a human, including authority over the use of lethal force
- Autonomous robot: a robot that does not require direct human involvement, except for high-level mission tasking; such a robot can make its own decisions consistent with its mission without requiring direct human authorization, including decisions regarding the use of lethal force

### **Figure 1: Survey Definitions**

In the last section, the following categories of demographics questions were presented:

- 1) Age, gender, region of the world where the participant was raised (cultural background);
- 2) Educational background;
- 3) Current occupation, and policymaking, robotics research, and/or military experience, if any;
- 4) Attitude towards technology, robots, and war in general;
- 5) Level of spirituality.

Finally, the survey was concluded with an open-ended question, encouraging the participants to express any opinions or concerns not directly addressed by the earlier questions.

To avoid order bias, response choices were randomized where appropriate. In addition, we varied the order in which the questions involving human soldier, robot as an extension of human soldier, and autonomous robot were presented. This was accomplished by creating two different versions of the survey, where the order was reversed in the second version; the participants are randomly assigned to each of the survey versions.

### *2.3 SURVEY ADMINISTRATION*

The IRB-approved survey was administered online, hosted by a commercial survey company, *SurveyMonkey.com*. Prior to opening the survey to the general public, we conducted a pilot study to improve its quality and understandability. Twenty people, including those from all of the aforementioned community types, participated in the pilot study. Their answers and subsequent interviews with a number of the participants provided the basis for improving a number of minor issues with the survey, and allowed us to better estimate completion times.

For the actual survey administration we adopted the four-prong approach recommended in [8]

and [9] for internet surveys, which consists of sending pre-notification, invitation to participate, a thank you/reminder, and a more detailed reminder. For the majority of the survey participants though, in lieu of personal pre-notification, recruitment through postings to mailing lists, newsgroups, and other advertising methods was used.

### **2.3.1 Recruitment Procedure**

We recruited participants using a variety of means and venues, most of them online-based. This was challenging as we had to ensure the avoidance of being considered “spam” and thereby generating ill-will among recipients. Bulk e-mail was not used. The most targeted and widespread coverage we achieved was among the robotics research community, as greater support for access was available. In particular, to solicit responses from robotics researchers we placed the survey announcements in the IEEE Robotics and Automation Society electronic newsletter, IEEE Robotics and Automation Magazine (June 2007 issue), in handouts distributed at the IEEE ICRA 2007 and RSS 2007 conferences and at RoboCup 2007. We also posted three calls for participation to comp.robotics.misc and comp.robotics.research newsgroups, as well as put a link to the survey invitation off the Mobile Robotics Lab website at Georgia Tech and Professor Arkin’s home webpage.

The rest of the community types, namely policymakers, military and general public, were recruited in the following manner:

- 1) By posting a survey announcement/invitation on a number of discussion/interest groups (including those that had military affiliation) on myspace.com, groups.yahoo.com, groups.google.com, and askville.com.
- 2) By press articles in the Economist magazine (July 2007 issue), Der Spiegel (August 2007 issue), Military History Magazine (October 2007 issue) and on BBC World News Radio website.
- 3) By posting to a number of newsgroups available through newsville.org.
- 4) By placing a survey announcement in the Georgia Tech Military Affinity Group’s May 2007 monthly news posting, and through handouts distribution to Georgia Tech Army ROTC.
- 5) By announcing the survey at a variety of talks and presentations given by Prof. Arkin, and through personal conversations.
- 6) By direct recruitment through e-mails to the Oregon and Georgia State Assemblymen and Congressmen, whose e-mail addresses were publicly available online.

With the exception of the last category (where a pre-notification e-mail and invitation to participate were sent directly to individuals), those who would like to participate in the survey had to request a link to the survey itself by first filling out a short online form. At this time we also requested self-confirmation that the participant was at least 18 years of age, due to the mature subject matter of the survey itself. Once such a request was received, each participant was assigned a unique ID; then an invitation for participation, along with a unique link to the survey, was sent by e-mail. This is done in part to track which recruitment methods were effective, and in part to prevent people from answering multiple times, or web-bots randomly filling out the survey.

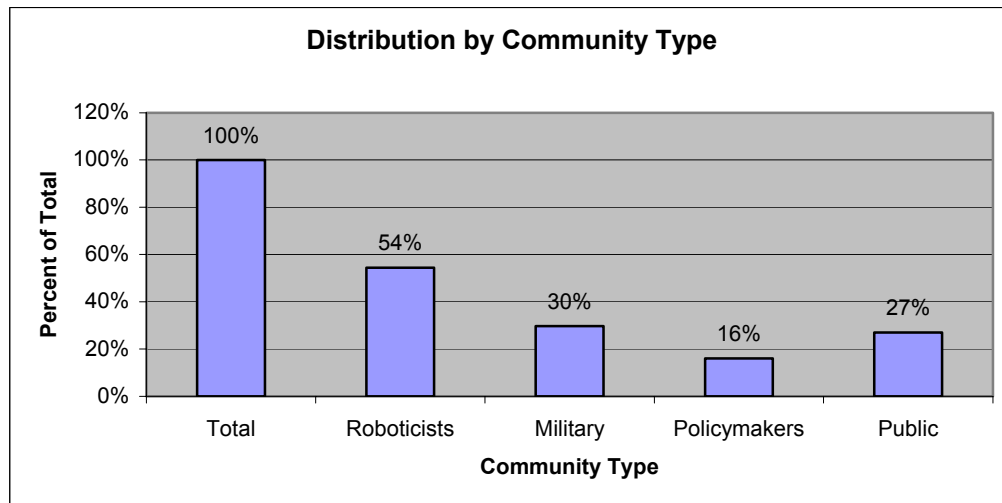
In addition to the above recruitment methods, we received requests for survey participation from those who heard of the survey by word of mouth and through miscellaneous individual blog postings that resulted from the aforementioned advertising efforts.

## 2.4 SURVEY RESPONSE STATISTICS

The survey was closed to the public on October 27<sup>th</sup>, 2007. A total of 634 people requested participation in the survey, out of which 16 e-mail addresses were invalid, resulting in 618 invitations to participate that reached their destination. Out of 618 people who received the invitations, 504 (82%) responded to this invitation. Additionally, pre-notification and invitation e-mails were sent directly to 268 Georgian and Oregonian senators and assemblymen, resulting in only 13 (5%) responses. Combined, a total of 517 participants responded to the survey, of which 430 were considered sufficiently complete to be used in the subsequent analysis.

Survey responses were considered incomplete if the information regarding participants' involvement in robotics research, policymaking or military experience was missing, as such information is indispensable for the data analysis concerning community types. The largest response drop off (43% of all incompletes) was observed at the beginning of the second section, where the two sets of questions began inquiring about in which roles and situations it would be acceptable to employ human soldiers, robots as extensions of human soldiers, and autonomous robots. The next largest drop off was observed immediately after the consent form, before a single question was answered (24% of incompletes). Only 1 person of 87 incompletes skipped the demographics section after filling out the rest of the survey. This distribution suggests that those participants who failed to finish the survey most likely did so due to their discomfort with the subject matter, specifically the material regarding employing robots in a lethal capacity. The length of the survey or other considerations did not appear to be a problem.

According to community type, the distribution is as follows: out of 430 participants who fully completed the survey, 234 self-identified themselves as having had robotics research experience, 69 having had policymaking experience, 127 having had military experience, and 116 having had none of the aforementioned (therefore categorized as general public). Figure 2 presents the distribution. Some participants expressed more than one type of experience resulting in an overlap: 27% of roboticists had military background, and 16% had policymaking experience.



**Figure 2: Distribution of Survey Participants by Community Type, Percent of the Total**

Due to the more targeted recruitment of roboticists and, perhaps, a greater interest they may have had in the survey, a majority of the participants (54%) belonged to the robotics research community type.

## *2.5 COVERAGE ERROR AND RESULTS SIGNIFICANCE.*

Due to insufficient resources, it was not feasible to send the survey by mail to a randomly distributed population; therefore the sample collected suffers from coverage error and does not fully represent the target population. As the survey was done online, the first source of potentially significant coverage error lies in the fact that only those who had access to Internet could participate in the survey. The second source of coverage error lies in the fact that, trying to avoid being considered “spam”, we could only advertise in certain venues, thus limiting potential participants to those who had access to those venues (e.g., certain magazines and newgroups). Finally, as we had no control over who would request survey participation, our participants were a self-selected group by interest, rather than a randomly distributed sample. Given these caveats, the data we present are mostly descriptive and qualitative, providing more of a big picture rather than a more rigorous statistical analysis. One exception, however, to this is the robotics researchers’ data, which, we believe, suffer the least from coverage error and non-random distribution. We can reasonably assume universal Internet access among the roboticists, and we were able to cover a significant portion of the population by advertising in highly relevant venues. Therefore, statistical analysis for the roboticist demographic only will be presented.

## **3. COMPARATIVE ANALYSIS**

In this section, first we present the big picture comparing the four community types (general public, robotics researchers, military and policymakers) and the entire data set in terms of percentages of participants answering questions in specific ways. This comparative analysis is followed by a more detailed view of the entire data set in Section 4. In Section 5, a statistical analysis of the robotics researcher community type will be given.

The main section of the survey consisted of questions 6-22 (see Appendix A for a complete list). These questions were thematically separated into Roles, Situations, Ethical Considerations, Responsibility, and Others, and are presented in this order below.

### *3.1 ROLES AND SITUATIONS*

The main section of the survey started with two sets of questions: the first one exploring the roles in which it would be acceptable to employ human soldiers and robots, and the second one focusing on the types of situations where lethality might be used. Both sets consisted of 3 questions each for three different cases, one regarding employing a human soldier, one using a robot as an extension of a human soldier, and the last one for an autonomous robot. Opinions on each role and situation were measured on a 5-point Likert-style scale, ranging from Strongly Agree (1) to Agree (2) to Neither Agree Nor Disagree (3) to Disagree (4) to Strongly Disagree (5). In addition, the participants also had a “No Opinion/Don’t Know” option (this option was treated as missing data in the subsequent analysis of all the survey questions).

As mentioned earlier, the order of the questions in each set was counterbalanced. In version A, the questions regarding the human soldier were presented first, followed by the robot as an extension, followed by the autonomous robot; this order was reversed in version B.

#### **3.1.1 Roles Set: Questions 6-8**

The Roles set of questions was designed to determine acceptance of the entities of different levels of autonomy in a variety of roles. Question 6 of this set was worded as follows (Figure 3):



**Figure 3: Roles Question**

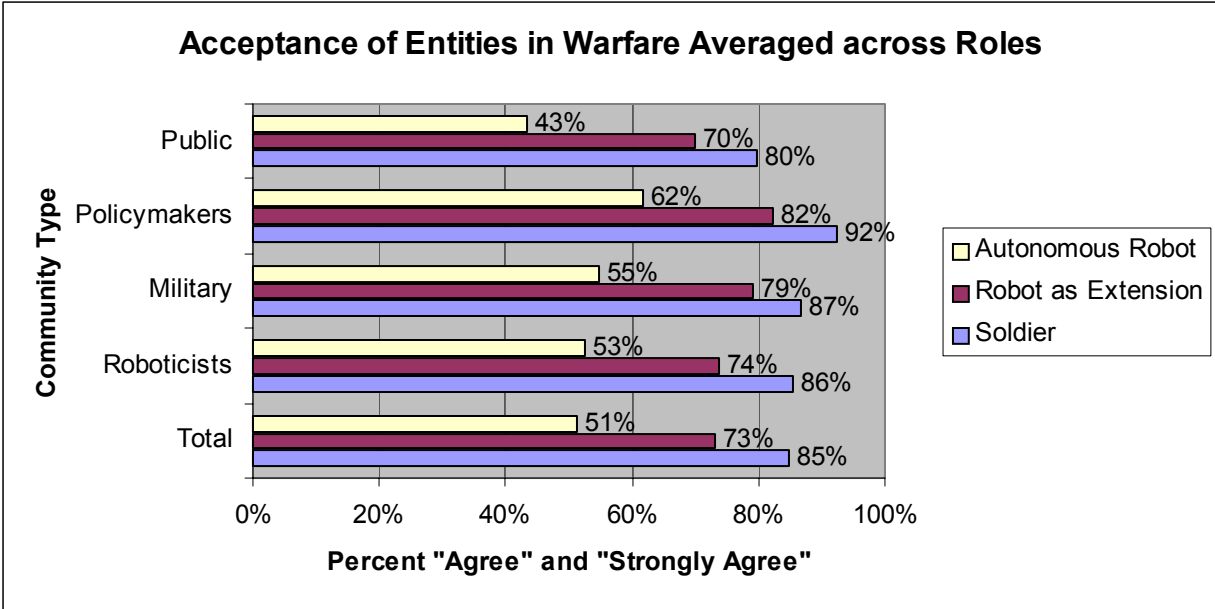
For questions 7 and 8 the underlined section was replaced with the other levels of autonomy, namely robot as an extension in question 7, and autonomous robot in question 8. When this question was asked with regards to an autonomous robot, the phrase “operating under the same rules of engagement as for a human soldier” was added. The following subsection provides a comparison between all three questions in the Roles set - between the three levels of autonomy.

**Levels of Autonomy**

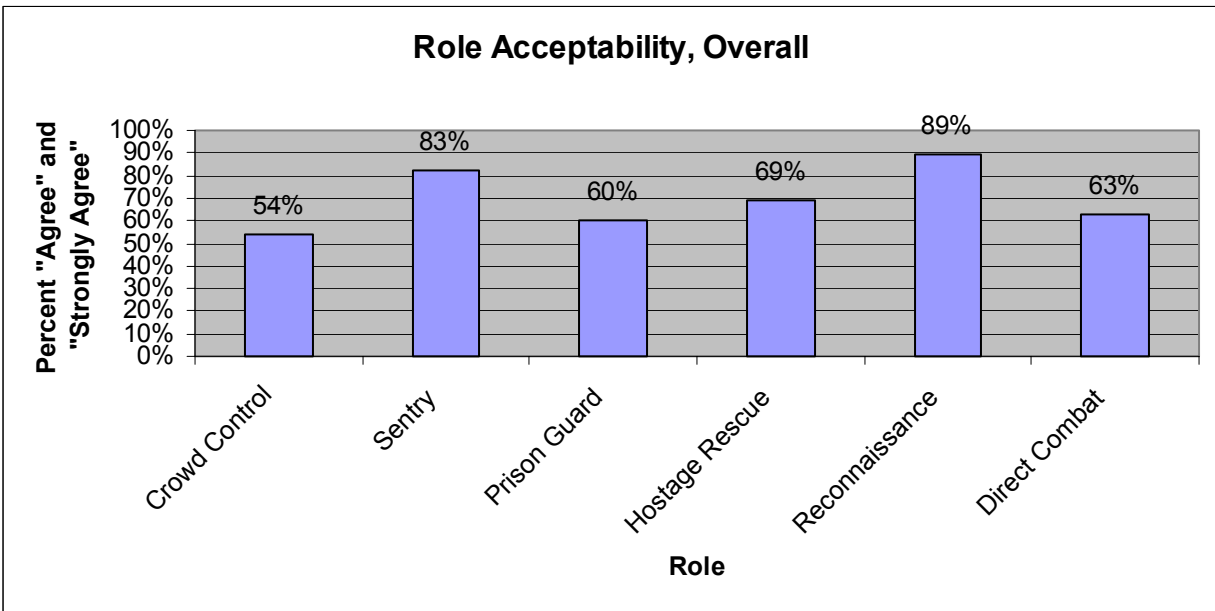
Figure 4 gives an idea of how acceptable soldiers and robots are to different community types, regardless of the role they may take. In general, a human soldier appears to be the most acceptable - 85% of all the participants responded “Agree” or “Strongly Agree” to the Roles question as averaged across all roles. Robot as an extension followed fairly closely in terms of its acceptability, with 73% of all participants agreeing/strongly agreeing to its use. Finally, an autonomous robot is shown as the least acceptable entity, with only 51%, or slightly more than half of all respondents accepting its use. This suggests that, in general case, the more control shifts away from the human to the robot, the less such a robot is acceptable to the participants. There is a larger gap between autonomous robot and robot as extension (22%) than between soldier and robot as an extension (12%), suggesting that an autonomous robot is perceived to have greater control over its actions than robot as an extension. As far as the community types are concerned, the general public finds the employment of soldiers and robots less acceptable than any other community type, and, conversely, policymakers find such employment more acceptable.

**Roles**

The data also suggest that not all roles are equally acceptable to the respondents (Figure 5). In particular, the roles of Reconnaissance (89% of all respondents answered “Agree” or “Strongly Agree”) and Sentry (83%) are deemed the most appropriate for use of soldiers and robots (averaged across all levels of autonomy), and where Crowd Control is the least acceptable role (54%).

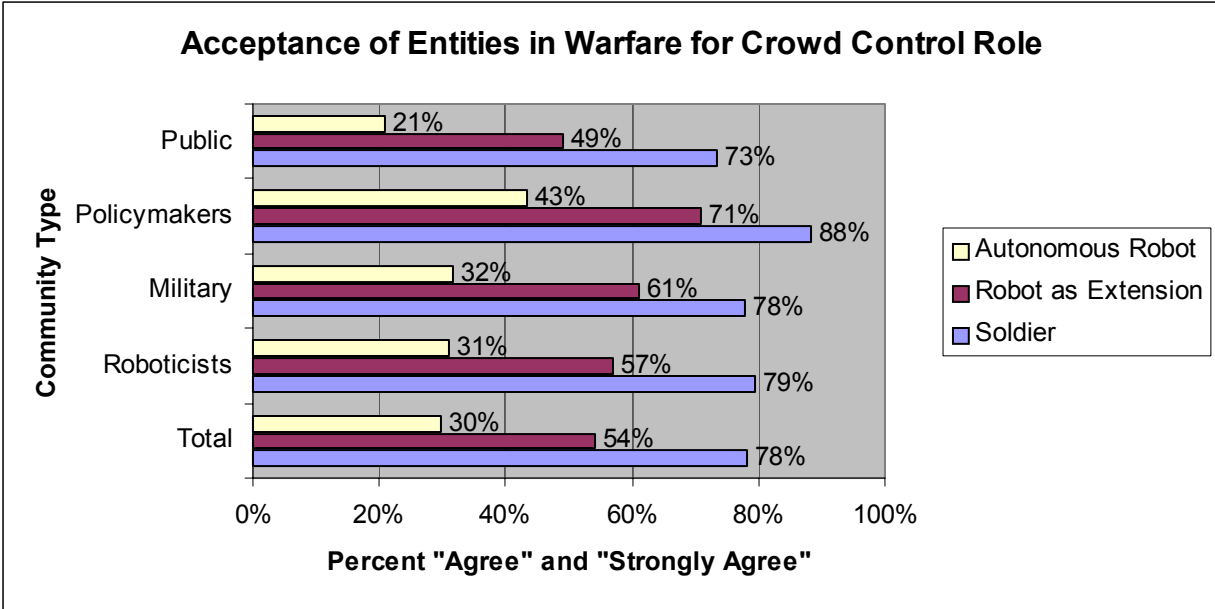


**Figure 4: Comparison by Community Type of Soldier and Robot Acceptance, Averaged across Roles. Note that the soldier is the most acceptable entity in warfare, regardless of the community type; followed by robot as an extension, and then autonomous robot. The difference between community types is not very pronounced overall; the general public is the least accepting of any entities in warfare, especially so in the case of an autonomous robot.**



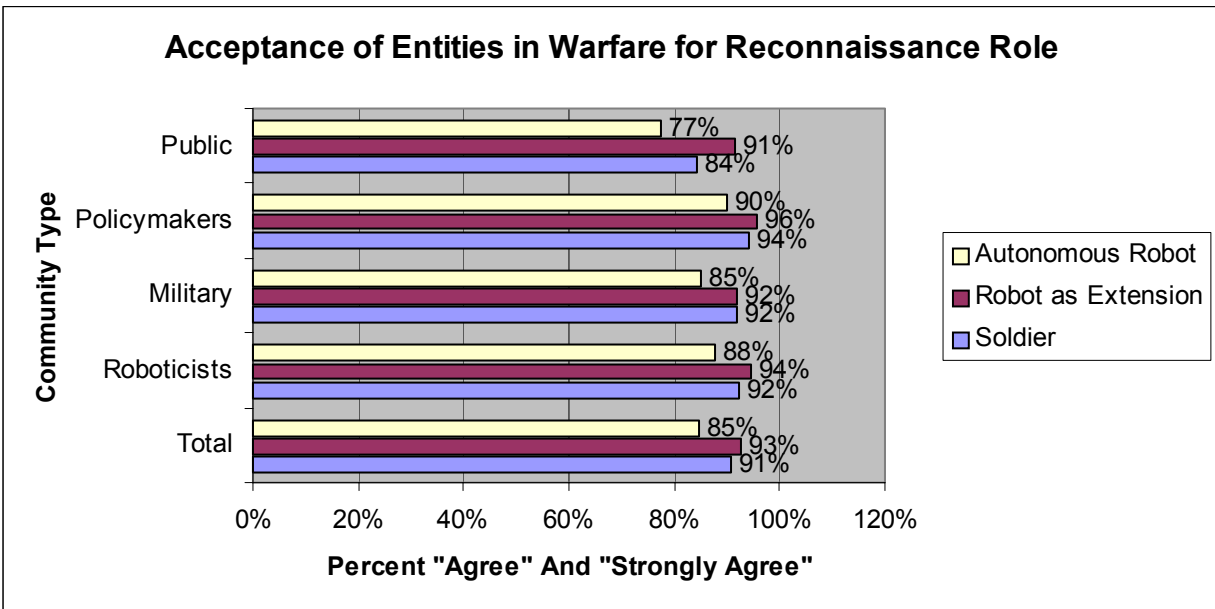
**Figure 5: Role Acceptability by All Participants, Averaged across Levels of Autonomy. The roles of Reconnaissance and Sentry are the most acceptable, and the role Crowd Control – the least.**





**Figure 6: Percent of participants who answered “Agree” or “Strongly Agree” for Crowd Control role. Note the large discrepancy in the acceptance between soldier and autonomous robot: while a human soldier is mostly accepted in this role, an autonomous robot is not.**

Conversely, there is hardly any difference between the levels of autonomy for Reconnaissance; in fact, the general public, roboticists, and policymakers all find a robot as an extension of the soldier more acceptable in this role than a human soldier (Figure 7). One possible explanation for this lies in the extent of possible human interaction: robots are less acceptable for roles in which the use of force with non-combatants is expected.



**Figure 7: Percent of participants who answered “Agree” or “Strongly Agree” for Reconnaissance Role. Note that the difference in acceptance for the three levels of autonomy is small.**

### 3.1.2 Situations Set: Questions 9-11

The Situations set of questions was designed to determine acceptance of the entities of different levels of autonomy in a variety of broad situations involving lethal force. Question 9 of this set was worded as follows (Figure 8):

9. To what extent do you agree or disagree that it is acceptable for a human soldier to take human life, in a manner consistent with the existing laws of war, in EACH of the following situations:

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Open warfare, with the war on foreign territory | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Open warfare, with the war on home territory    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on foreign territory          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on home territory             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 8: Situations Question**

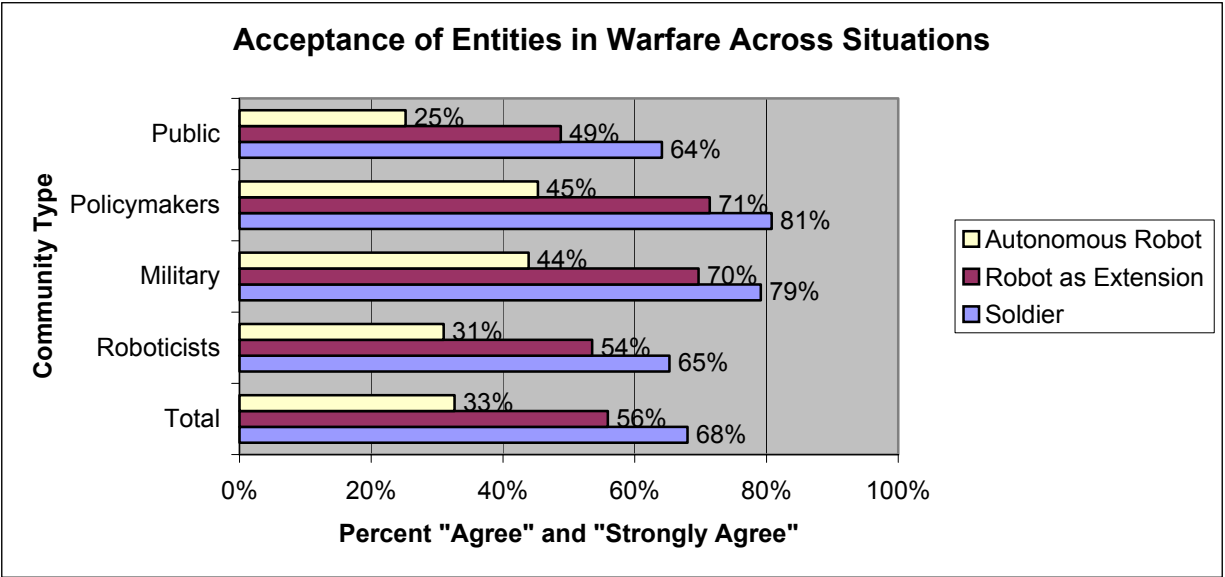
For questions 10 and 11 the underlined section was replaced with the other levels of autonomy, namely robot as an extension in question 10, and autonomous robot in question 11.

#### Levels of Autonomy

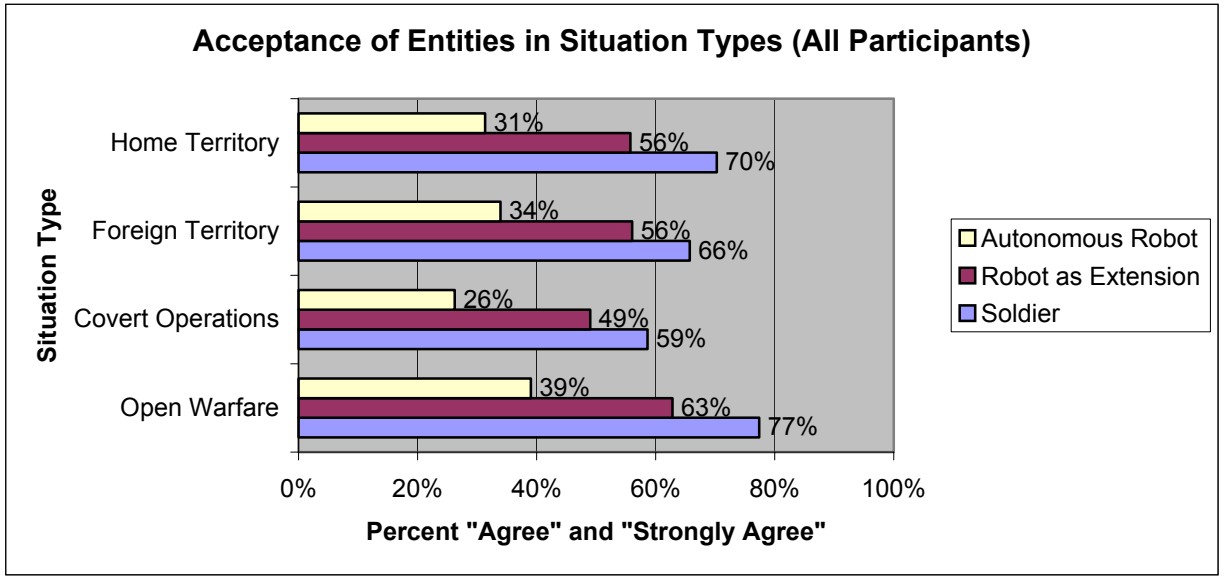
Figure 9 gives an idea of how acceptable soldiers and robots are to different community types, regardless of the situation they may participate in. Similar to the Roles set, the acceptance of soldiers and robots depends on the level of autonomy, and the farther control is removed from the human, the less desirable the participants found the entity: robot as an extension was found more acceptable than autonomous robot. Additionally, employing any of the entities in the proposed situations turned out to be less acceptable than employing them in the proposed roles (overall, only 68% of all participants answered “Agree” or “Strongly Agree” to the Situations questions with regards to soldier, 56% with regards to robot as an extension, and 33% with regards to autonomous robot, compared to 85%, 73% and 51%, respectively for the Roles questions). One possible explanation for such a difference could be the wording of the questions: only the Situations set of questions inquired about the acceptability of taking human life. As with the Roles set, the general public was the least likely community type to accept employing either soldiers or robots in these situations. Military and policymakers, in contrast, were the most likely to agree that using soldiers or robots is acceptable.

#### Situations

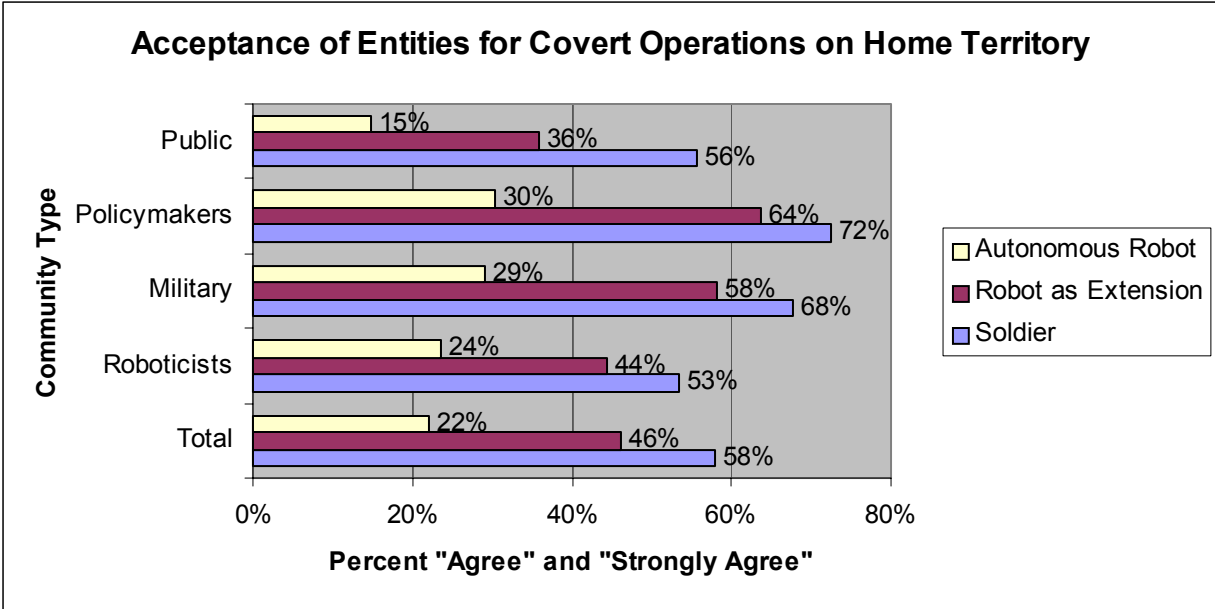
Covert Operations were less acceptable to the entire set of participants than Open Warfare (whether on Home or Foreign Territory, Figure 10), with Covert Operations on Home Territory being the least desirable of all situations (Figure 11; see also Appendix B.2 for the information on Open Warfare on Foreign Territory). In this situation, only 58% of the participants answered “Agree” or “Strongly Agree” for a human soldier, 46% - for a robot as an extension, and 22% for an autonomous robot, compared to 68%, 56% and 33%, respectively, as averaged across all situations. The general public, again, was the least accepting, especially in the case of an autonomous robot (only 15% acceptance compared to 30% acceptance by policymakers).



**Figure 9: Levels of Autonomy by Community Type Across Situations. The same trend in acceptance for the levels of autonomy is evident as for the Roles set: soldier is the most accepted entity, followed by robot as an extension, then autonomous robot. Also note that general public was the least likely to accept any of the entities in warfare, while policymakers and higher-level military authorities – the least.**



**Figure 10: Situations Types Grouped by Territory and Warfare Type. Covert Operations are less Acceptable than Open Warfare.**



**Figure 11: Covert Operations on Home Territory by Level of Autonomy and Community Type. This situation was the least accepted by the participants, with general public being the least accepting, and policymakers the most.**

*3.2 ETHICAL CONSIDERATIONS: QUESTIONS 12-15*

This section contains four questions, the first two of which differ only in whether the object of the question is a human soldier or an autonomous robot. The first and second questions in the Ethical Considerations subsection are shown in Figure 12 and Figure 13, respectively.

**12. In your opinion, for a human soldier to act in an ethical manner during warfare means:**

|   | Yes                   | No                    | Don't Know            |
|---|-----------------------|-----------------------|-----------------------|
| a) Following international protocols that specify the laws for ethical conduct of war, such as the Geneva Convention      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b) Following rules of engagement that specify rules which should guide actions during specific situations in the military | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c) Following a code of conduct which specifies how to behave in general in the military                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d) Following additional moral standards, above and beyond those specified in parts a-c                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 12: Question 12 – Ethical Considerations**

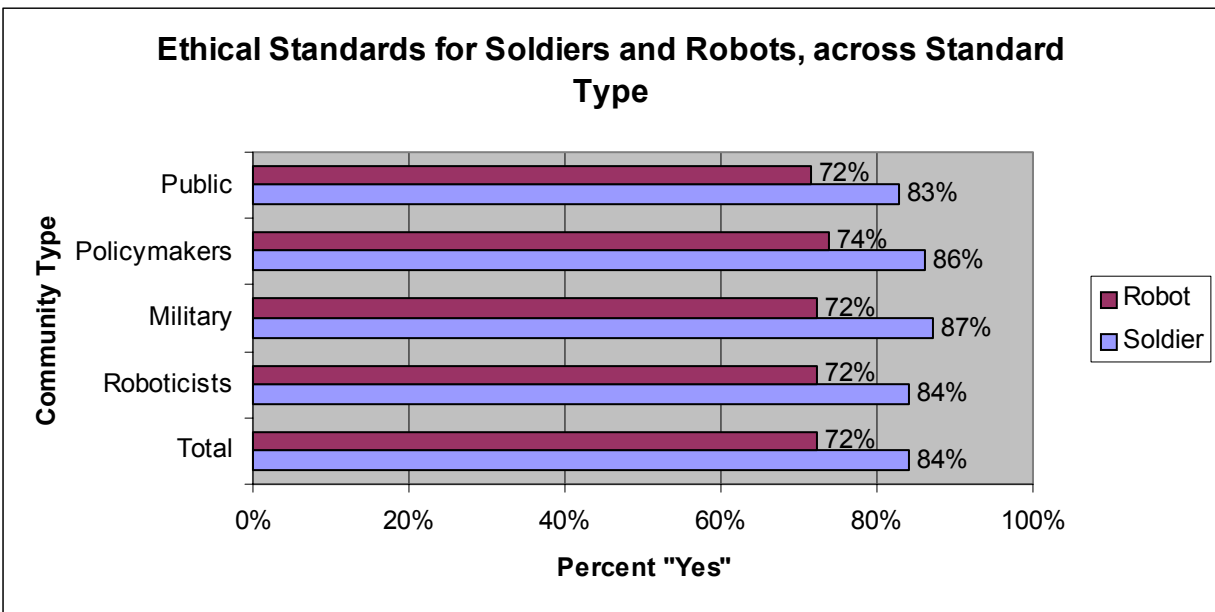
**13. In your opinion, for an autonomous military robot to act in an ethical manner during warfare means:**

|   | Yes                   | No                    | Don't Know            |
|---|-----------------------|-----------------------|-----------------------|
| a) Following international protocols that specify the laws for ethical conduct of war, such as the Geneva Convention      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b) Following rules of engagement that specify rules which should guide actions during specific situations in the military | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c) Following a code of conduct which specifies how to behave in general in the military                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d) Following additional moral standards, above and beyond those specified in parts a-c                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 13: Question 13 – Ethical Considerations**

The answer choices for these two questions were “Yes”, “No”, and “No Opinion/Don’t

Know” for each category (a-d). These questions intended to uncover whether the standards commonly used for human soldiers in warfare could also be applied to autonomous robots. As seen in Figure 14, the vast majority of the participants, regardless of the community type, agreed that the ethical standards presented in this question do apply to both soldiers and robots (84% and 72%, respectively). However, these standards seem to be more applicable to soldiers than to robots (12% difference in the overall case); this difference doesn’t necessarily mean that robots are not supposed to adhere to ethical standards as stringently as humans, but rather that there is perhaps a somewhat different set of standards for robots to adhere to.



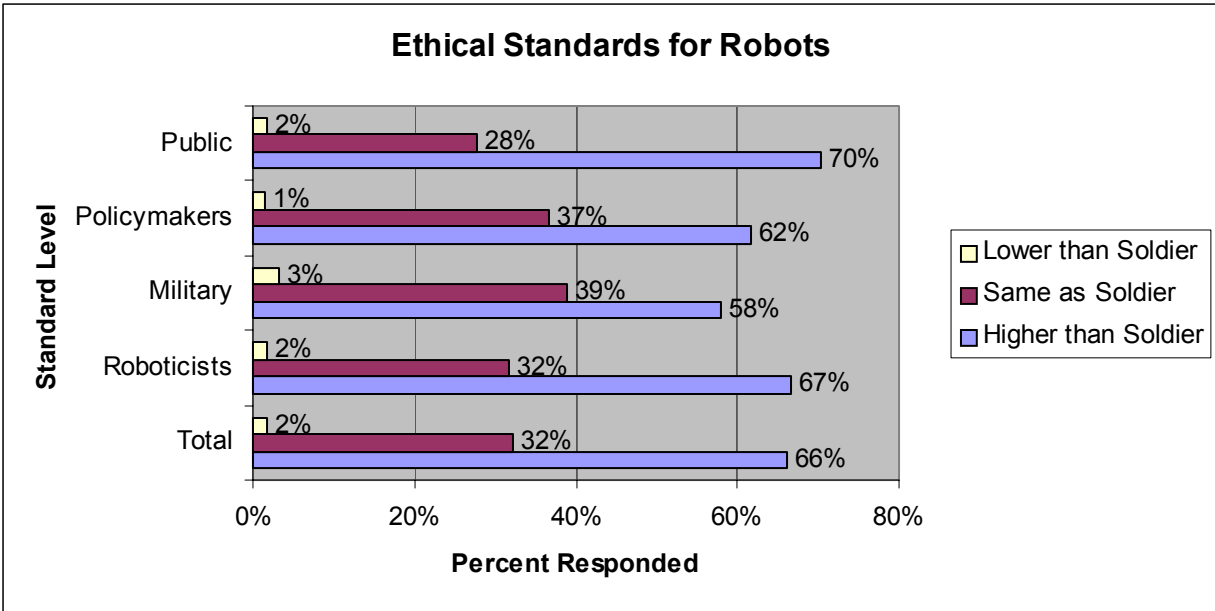
**Figure 14: Behaving Ethically in Warfare. There is hardly any difference in the opinions of different community types.**

The answers to the next question, indeed, confirm the supposition that ethical standards for robots should not be more lax than those for human soldiers, but rather to the contrary (the question wording is given in Figure 15; the order of the response options was randomized). As seen in Figure 16, hardly any participants, regardless of the community type, said that robots should be held to lower standards than a human soldier (66% of all participants were in favor of higher ethical standards, 32% in favor of the same standards, and 2% were in favor of lower standards). More of those with military experience and policymakers were in favor of the same standards for both soldiers and robots than the general public and roboticists, who were more in favor of higher standards for robots.

**14. If robots could act ethically in warfare, to what ethical standards should they be held to? Please pick one:**

- Higher ethical standards than a human soldier
- Lower ethical standards than a human soldier
- The same ethical standards as a human soldier

**Figure 15: Question 14 – Ethical Considerations**



**Figure 16: Ethical Standards For Robots by Community Type. The majority of the participants were in favor of higher than or the same ethical standards for robots as for human soldier.**

Finally, the last question in this subsection asked whether it is appropriate for a robot to refuse an unethical order from a human (Figure 17).

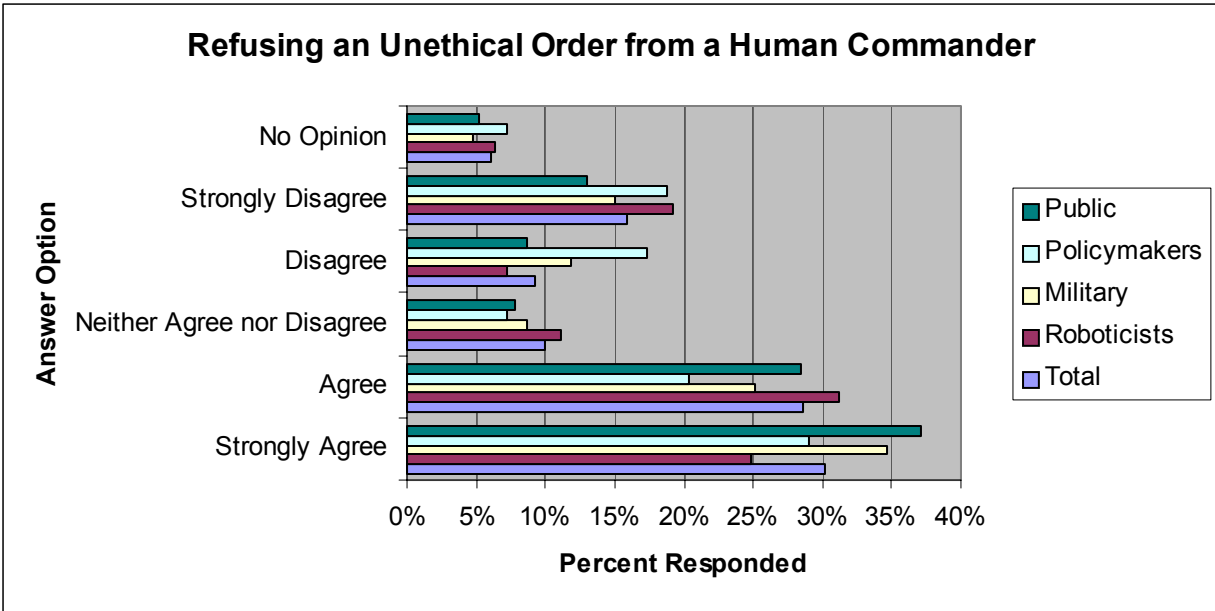
15. To what extent do you agree or disagree that an autonomous military robot should be able to refuse an order from a human commander it interprets to be unethical?

Strongly Agree   
 Agree   
 Neither Agree nor Disagree   
 Disagree   
 Strongly Disagree   
 No Opinion/ Don't Know

**Figure 17: Question 15 – Ethical Considerations**

The answer choices for Question 15 ranged on a 5-point scale from “Strongly Agree” to “Strongly Disagree”, with “No Opinion/Don’t Know” as an additional option at the end of the scale.

Although the majority of all participants (59%) agrees or strongly agrees that it is acceptable for a robot to refuse an unethical order, there is also a significant portion (16%) of those who strongly disagree with this statement (Figure 18, Table 1). This question also resulted in a larger than usual percentage of those who chose “No Opinion” option (6% of all participants), suggesting that it was hard for some of the respondents to make a decision on this issue. Overall, however, it was considered more important for a robot to behave ethically than to stay under the control of a human, as the majority gave robots a right to refuse an unethical order.



**Figure 18: Refusing an Unethical Order from a Human Commander by Community Type. The majority of the participants find it acceptable for a robot to refuse an unethical order.**

|                                   | Total | Roboticists | Military | Policymakers | Public |
|-----------------------------------|-------|-------------|----------|--------------|--------|
| <b>Strongly Agree</b>             | 30%   | 25%         | 35%      | 29%          | 37%    |
| <b>Agree</b>                      | 29%   | 31%         | 25%      | 20%          | 28%    |
| <b>Neither Agree nor Disagree</b> | 10%   | 11%         | 9%       | 7%           | 8%     |
| <b>Disagree</b>                   | 9%    | 7%          | 12%      | 17%          | 9%     |
| <b>Strongly Disagree</b>          | 16%   | 19%         | 15%      | 19%          | 13%    |
| <b>No Opinion</b>                 | 6%    | 6%          | 5%       | 7%           | 5%     |

**Table 1: Refusing an Unethical Order by Community Type**

As far as the community types are concerned, policymakers were the least in favor of such order refusal - only 49% of policymakers agreed or strongly agreed, compared to the general public with a 66% positive response (see Appendix B.3 for the graph).

### 3.3 RESPONSIBILITY: QUESTIONS 16-18

This subsection contained a set of three questions, one for each level of autonomy. These questions were designed to determine who is responsible in the event that one of the entities makes a lethal error in war. The answer choices ranged on a 5-point scale from “Very Significantly” to “Not at All”, with “No Opinion/Don’t Know” as an additional option at the end of the scale. The question regarding a human soldier read as follows (Figure 19):



16. In general, if a **human soldier** takes a human life in error, to what extent could EACH of the following parties be responsible?

|                                   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|-----------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Human soldier                     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Higher-level military authorities | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Politicians                       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 19: Responsibility Question – Human Soldier**

Figure 20 displays the responsibility question in regards to a robot as an extension. Please note that the choice of responsible parties in that case is different: Robot Itself and Robot Designer options are added.

17. In general, if a **military robot as an extension of a human soldier** takes a human life in error, to what extent could EACH of the following parties be responsible?

|                                       | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|---------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Robot itself                          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Human soldier in control of the robot | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Robot designer                        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Higher-level military authorities     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Politicians                           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 20: Responsibility Question – Robot as Extension**

Finally, the “Human soldier in control of the robot” option was taken out in the case of the autonomous robot entity (Figure 21), as compared to the robot as an extension case.

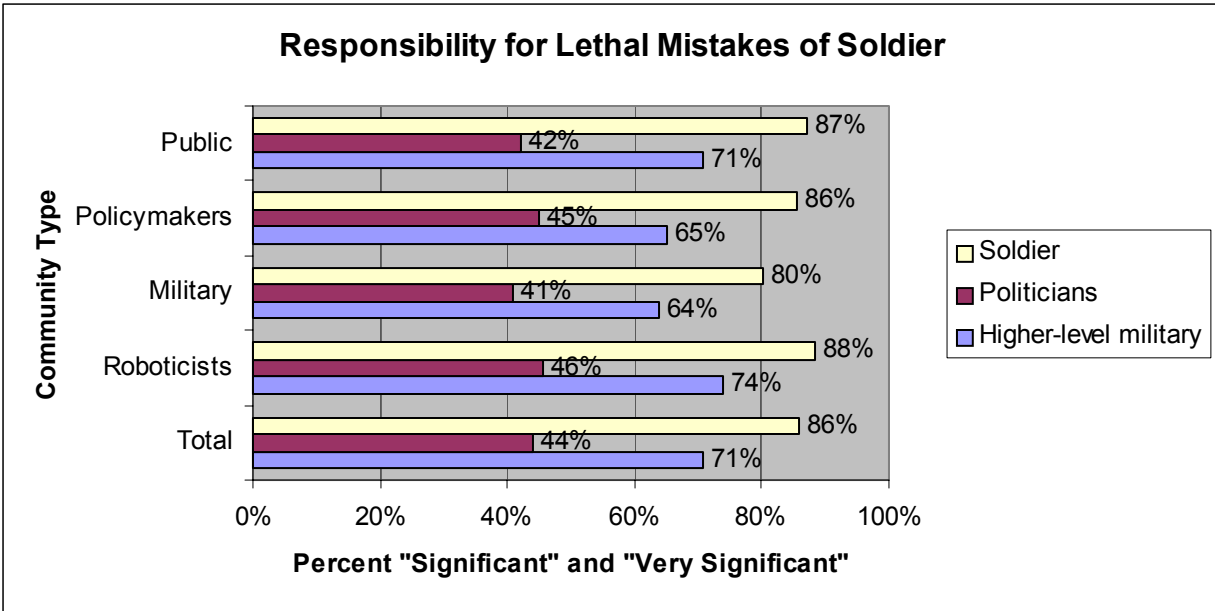
18. In general, if an **autonomous military robot** takes a human life in error, to what extent could EACH of the following parties be responsible?

|                                   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|-----------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Robot itself                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Robot designer                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Higher-level military authorities | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Politicians                       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 21: Responsibility Question – Autonomous Robot**

As seen in Figure 22, the soldier is the party considered most responsible for his/her lethal mistakes overall (86% of all participants answered “Significantly” and “Very Significantly”), though the military respondents attributed slightly less blame to the soldier than did other community types. Higher-level military authorities were found to be moderately responsible, with 71% (both military and policymakers attributed somewhat less blame to this party than the general public or roboticists). Finally, less than half of the participants (44%) blamed politicians.

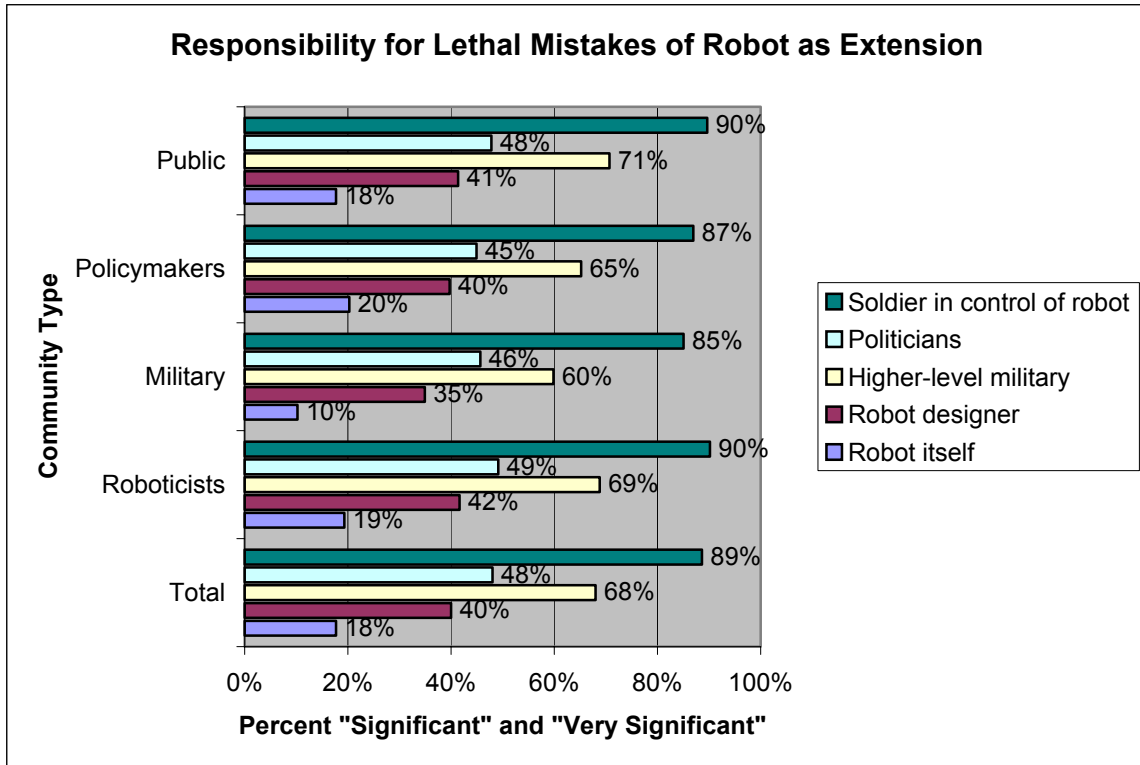




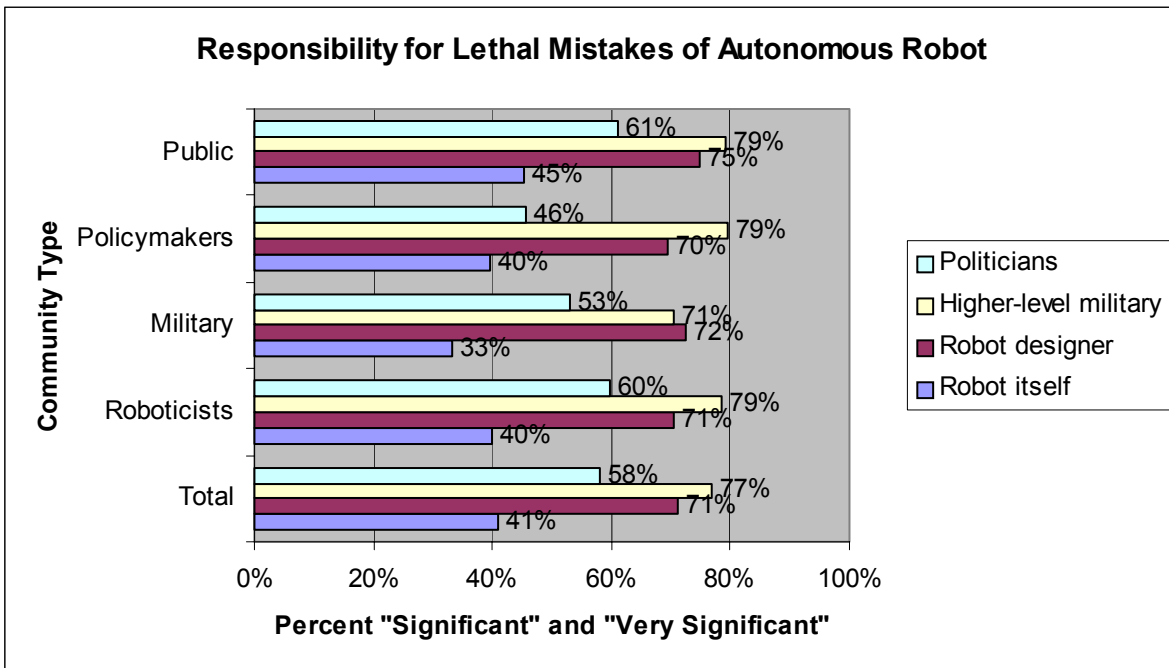
**Figure 22: Responsibility for Lethal Mistakes of Soldier by Community Type. Soldier was found to be the most responsible for his/her mistakes, and politicians – the least.**

A similar trend with respect to higher-level military authorities and politicians, as well as the soldier in control of the robot, is displayed in the case of robot as an extension (Figure 23). The soldier is still the most responsible party (89% of all participants said “Significantly” or “Very Significantly”), even though the actual errors are made by robot; followed by higher-level military authorities (68%) and politicians (48%). The robot designer is deemed even less responsible than politicians (41%), and only 18% of all participants would hold the robot itself responsible for its actions. The military attributed the least amount of blame to any of the responsible parties (with the exception of politicians) than any other community type.

Finally, in the absence of the soldier in control of the robot for the autonomous robot case (Figure 24), the most responsible party is higher-level military authorities (77% of all participants answered “Significantly” and “Very Significantly”), followed closely by the robot designer (71%). Although the robot itself is still the least responsible party (41%), it is blamed more than twice as much as the robot as an extension (18%). Notice also that the robot designer is also blamed significantly more in this case (by 31%) than in case of robot as an extension. This suggests that as the control shifts away from the soldier, the robot and its maker should take more responsibility for the robot’s actions. It is interesting that the military community type placed the robot designer as almost equally responsible as higher-level military authorities (72% and 71%, respectively), while policymakers thought that robot itself was almost as blameworthy as politicians (40% and 46%, respectively).



**Figure 23: Responsibility for Lethal Mistakes of Robot as an Extension by Community Type.** Note that the soldier is still found to be the most responsible party, followed by higher-level military authorities, with the robot itself being the least blameworthy.



**Figure 24: Responsibility for Lethal Mistakes of an Autonomous Robot by Community Type.** Higher-level military authorities are viewed as the most responsible party, followed closely by robot designer; robot itself was found to be the least responsible.

3.4 BENEFITS AND CONCERNS: QUESTIONS 19 AND 20

The two questions in this subsection explore the potential benefits of and concerns for using lethal military robots in warfare. Both questions were phrased in a similar manner, and benefits/concerns categories were the opposites of each other. The answer choices ranged on a 5-point scale from “Very Significantly” to “Not at All”, with “No Opinion/Don’t Know” as an additional option at the end of the scale. Figure 25 and Figure 26 display the Benefits and Concerns questions, respectively.

**19. To what extent do you think EACH of the following is a potential BENEFIT of using military robots capable of taking human life in warfare?**

|   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Saving lives of soldiers                                | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Saving civilian lives                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Reducing long-term psychological trauma to soldiers     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Reducing the financial cost of using soldiers in combat | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Producing better battlefield outcomes                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decreasing friendly fire incidents                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 25: Benefits Question**

**20. To what extent do you think EACH of the following is a potential CONCERN for using military robots capable of taking human life in warfare?**

|   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Risking lives of soldiers                                 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Risking civilian lives                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increasing long-term psychological trauma to soldiers     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increasing the financial cost of using soldiers in combat | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Producing worse battlefield outcomes                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Increasing friendly fire incidents                        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Figure 26: Concerns Question**

“Saving lives of soldiers” was considered the most clear-cut benefit, with 79% of all participants acknowledging it as a benefit (Figure 27, Table 2), followed by “decreasing long-term psychological trauma to soldiers” (62%) and “saving civilian lives” (53%). The rest of the proposed categories were less clear-cut, and were identified as benefits by less than half of the participants. Although in general the difference in opinions between the community types was slight, it is interesting to note that the general public and roboticists were less likely to identify “Saving civilian lives” as a benefit than politicians or military, and fewer roboticists believed that robots could help produce better battlefield outcomes.

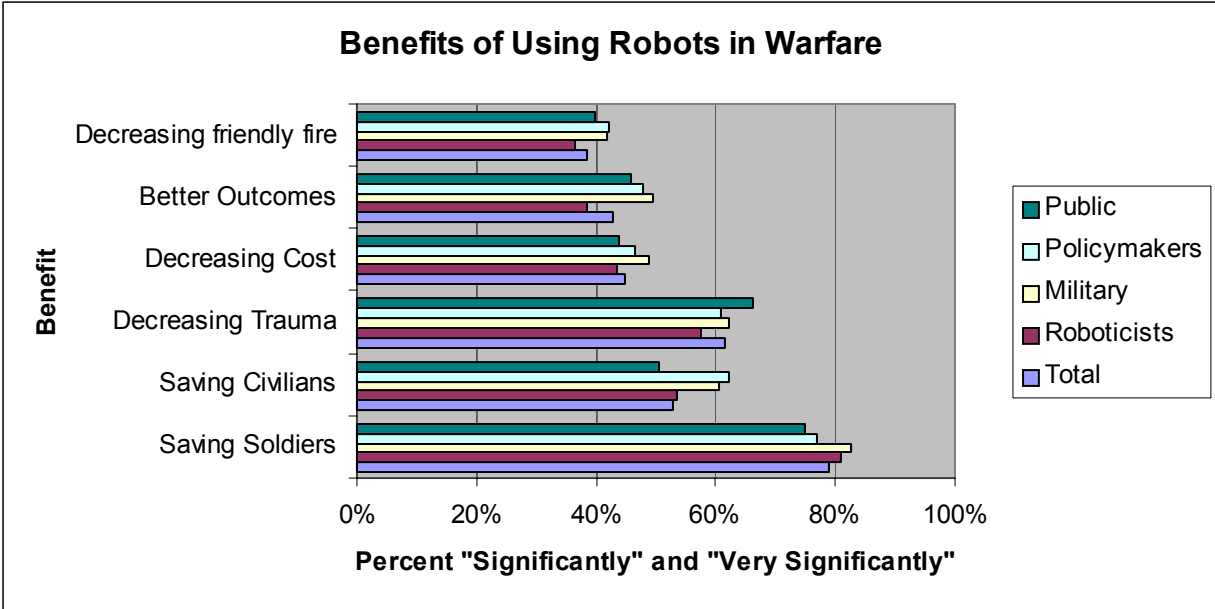


Figure 27: Benefits of Using Robots in Warfare by Community Type. “Saving lives of soldiers” was viewed as the most clear-cut benefit.

| BENEFIT                         | Total | Roboticians | Military | Policymakers | Public |
|---------------------------------|-------|-------------|----------|--------------|--------|
| <b>Saving Soldiers</b>          | 79%   | 81%         | 83%      | 77%          | 75%    |
| <b>Saving Civilians</b>         | 53%   | 53%         | 61%      | 62%          | 50%    |
| <b>Decreasing Trauma</b>        | 62%   | 58%         | 62%      | 61%          | 66%    |
| <b>Decreasing Cost</b>          | 45%   | 44%         | 49%      | 46%          | 44%    |
| <b>Better Outcomes</b>          | 43%   | 38%         | 50%      | 48%          | 46%    |
| <b>Decreasing friendly fire</b> | 38%   | 36%         | 42%      | 42%          | 40%    |

Table 2: Benefits of Using Robots in Warfare

The main concern for using robots in warfare was that of risking civilian lives, with 67% of all participants acknowledging it (Figure 28, Table 3); less than half of the participants considered any other categories as concerns. For all categories, the military respondents saw using robots in warfare as less of a concern than any other community type.

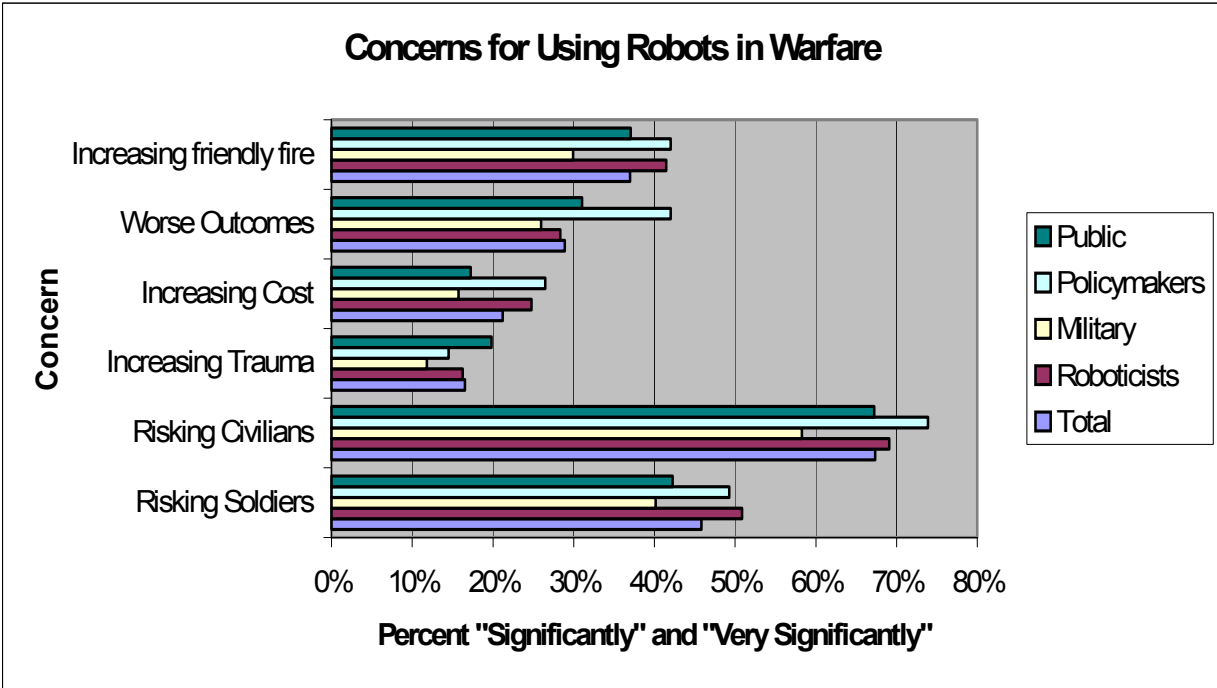


Figure 28: Concern for Using Robots in Warfare by Community Type. “Risking civilian lives” was viewed as the biggest concern.

| CONCERN                         | Total | Roboticists | Military | Policymakers | Public |
|---------------------------------|-------|-------------|----------|--------------|--------|
| <b>Risking Soldiers</b>         | 46%   | 51%         | 40%      | 49%          | 42%    |
| <b>Risking Civilians</b>        | 67%   | 69%         | 58%      | 74%          | 67%    |
| <b>Increasing Trauma</b>        | 17%   | 16%         | 12%      | 14%          | 20%    |
| <b>Increasing Cost</b>          | 21%   | 25%         | 16%      | 26%          | 17%    |
| <b>Worse Outcomes</b>           | 29%   | 28%         | 26%      | 42%          | 31%    |
| <b>Increasing friendly fire</b> | 37%   | 41%         | 30%      | 42%          | 37%    |

Table 3: Concern for Using Robots in Warfare

### 3.5 WARS AND EMOTIONS: QUESTIONS 21 AND 22

Finally, the last subsection of the main section of the survey explored two issues: whether introducing robots onto the battlefield would make wars easier to start, and whether certain emotions would be appropriate in a military robot.

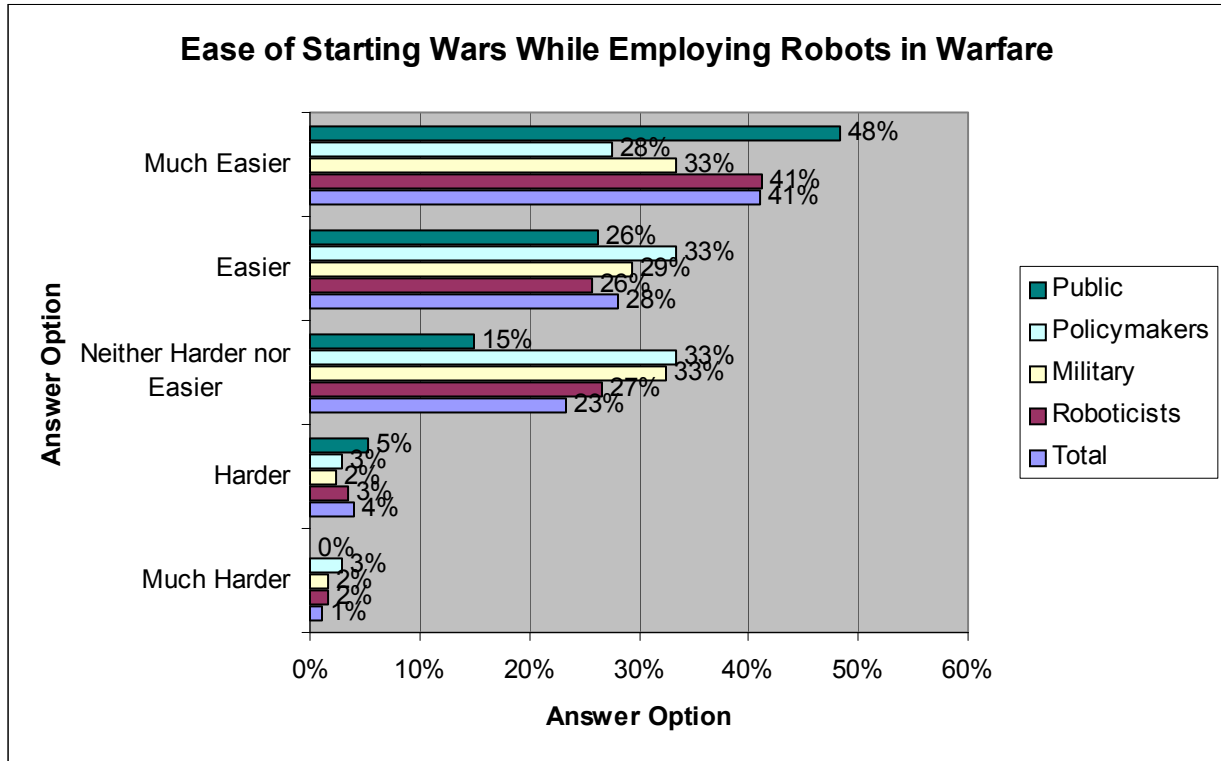
The answer choices for the “wars” question ranged on a 5-point scale from “Much Harder” to “Much Easier”, with “No Opinion/Don’t Know” as an additional option at the end of the scale. The Wars question was worded as follows (Figure 29):

21. To what extent do you think bringing military robots onto the battlefield would make it harder or easier for humans to start wars?

Much Harder   
 Harder   
 Neither Harder nor Easier   
 Easier   
 Much Easier   
 No Opinion/Don't Know

Figure 29: Ease of Starting Wars Question

Perhaps not surprisingly, “Much Easier” was the predominant choice (41%), especially given that “Saving lives of soldiers” from the previous question set was considered a significant benefit, suggesting that if less human losses are expected in wars, they may be easier to initiate. Only 5% of all participants believed that it would be harder or much harder to start wars with robots being deployed (Figure 30). The general public was the most pessimistic community on this issue, with 74% saying “Easier” or “Much Easier”, whereas only 61% of policymakers and 62% of the military respondents thought so.



**Figure 30: Ease of Starting Wars While Employing Robots in Warfare. The overwhelming majority believes it would be easier to start wars with robots deployed.**

Emotions have been implicated in ethical behavior [5], therefore the Emotions question was designed to identify which emotions people viewed as providing potential benefits to an ethical military robot. This question read as follows (Figure 31):

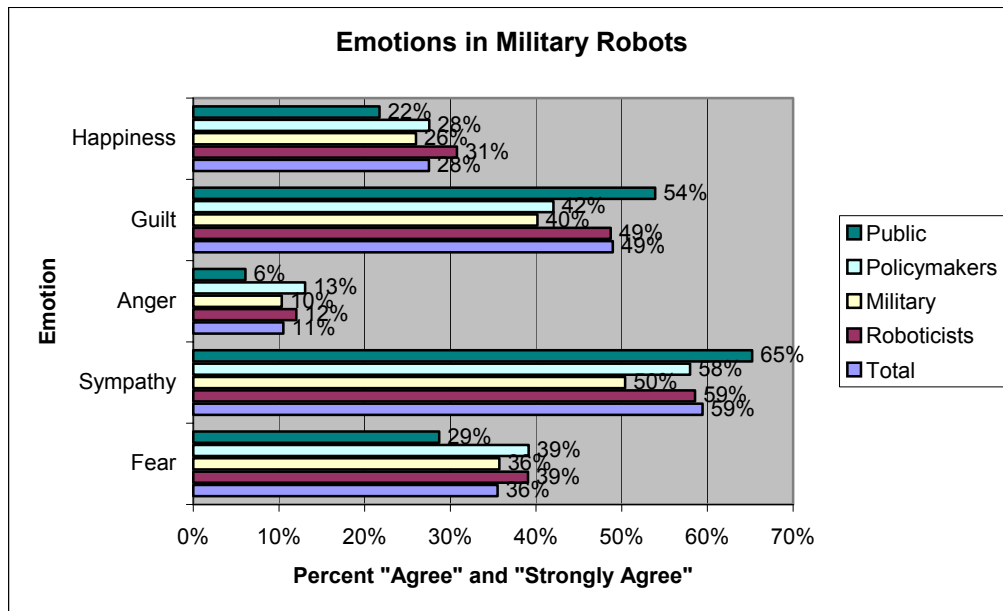
22. If it were possible for a military robot to have emotions, to what extent do you agree or disagree that EACH of the following emotions could be beneficial for it to have:

|           | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|-----------|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Fear      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Anger     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Guilt     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Happiness | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Sympathy  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

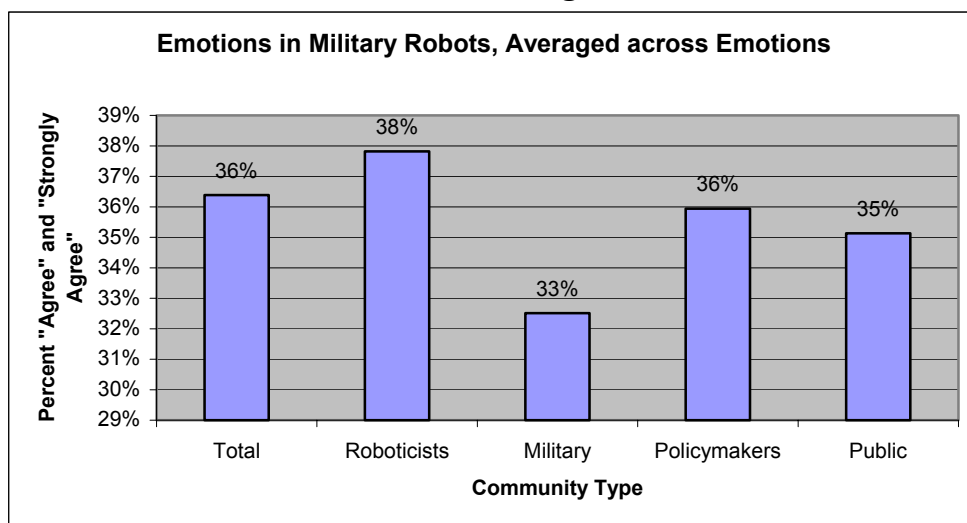
**Figure 31: Emotions Question**

The emotion categories were randomized, and the answer choices ranged on a 5-point scale from “Strongly Agree” to “Strongly Disagree”, with “No Opinion/Don’t Know” as an additional option at the end of the scale. Sympathy and guilt were considered to be the most likely emotions to benefit a military robot (Figure 32), with 59% and 49%, respectively, of all participants agreeing or strongly agreeing with the statement above. This finding suggests that people may be open to the idea of emotion in military robots if such emotions would make robots more humane and more responsible for their actions.

The general public favored sympathy and guilt more than any other community type; the military were the least likely to consider emotions in military robots (33% as averaged across all emotions), compared to 38% of roboticists who would entertain the idea (Figure 33).



**Figure 32: Emotions in Military Robots by Community Type. Sympathy was the most favored emotion, and anger – the least.**



**Figure 33: Emotions in Military Robots, Averaged across Emotions. Military were the least likely to consider emotions in military robots, and roboticists were the most likely.**

### 3.6 SUMMARY OF COMPARATIVE ANALYSIS

The findings in this section can be summarized as follows:

- As far as the community types are concerned, regardless of roles or situations, in most cases the general public found employment of soldiers and robots less acceptable than any other community type, and, conversely, military and policymakers found such employment more acceptable.
- The most acceptable role for using both types of robots in is Reconnaissance; the least acceptable is for Crowd Control.
- With respect to levels of autonomy, regardless of roles or situations, the more the control shifts away from the human, the less such an entity is acceptable to the participants; a human soldier was the most acceptable entity in warfare, followed by a robot as an extension of the warfighter, with autonomous robot being the least acceptable.
- As far as the situations are concerned, Covert Operations were less acceptable to the entire set of participants than Open Warfare for all three entities: soldiers and both types of robots (whether on Home or Foreign Territory).
- The majority of participants, regardless of the community type, agreed that the ethical standards, namely, Laws of War, Rules of Engagement, Code of Conduct and Additional Moral Standards, do apply to both soldiers (84%) and robots (72%).
- More military and policymakers were in favor of the same standards for both soldiers and robots than general public and roboticists, who were more in favor of higher standards for robots.
- 59% of the participants believed that an autonomous robot should have a right to refuse an order it finds unethical, thus in a sense admitting that it may be more important for a robot to behave ethically than to stay under the control of a human.
- As the control shifts away from the soldier, the robot and its maker should take more responsibility for its actions, according to the participants. A robot designer was blamed 31% less for the mistakes of robot as an extension than for those of an autonomous robot.
- “Saving lives of soldiers” was considered the most clear-cut benefit of employing robots in warfare; and the main concern was that of risking civilian lives by their use.
- The majority of the participants (69%) believe that it would be easier to start wars if robots were employed in warfare.
- Sympathy was considered to be beneficial to a military robot by over half of the participants (59%), and guilt by just under a half (49%).



#### 4. DETAILED ANALYSIS

This section presents a more detailed view of the entire data set, starting with the demographics. As the questions were presented in the same way to all community types, the wording of the questions is not repeated in this and all the subsequent sections. Please refer to Section 3 “Comparative Analysis” or Appendix A for the exact wording. Some results from the entire data set were already partially presented in the previous section; therefore some questions will be omitted from the current section.

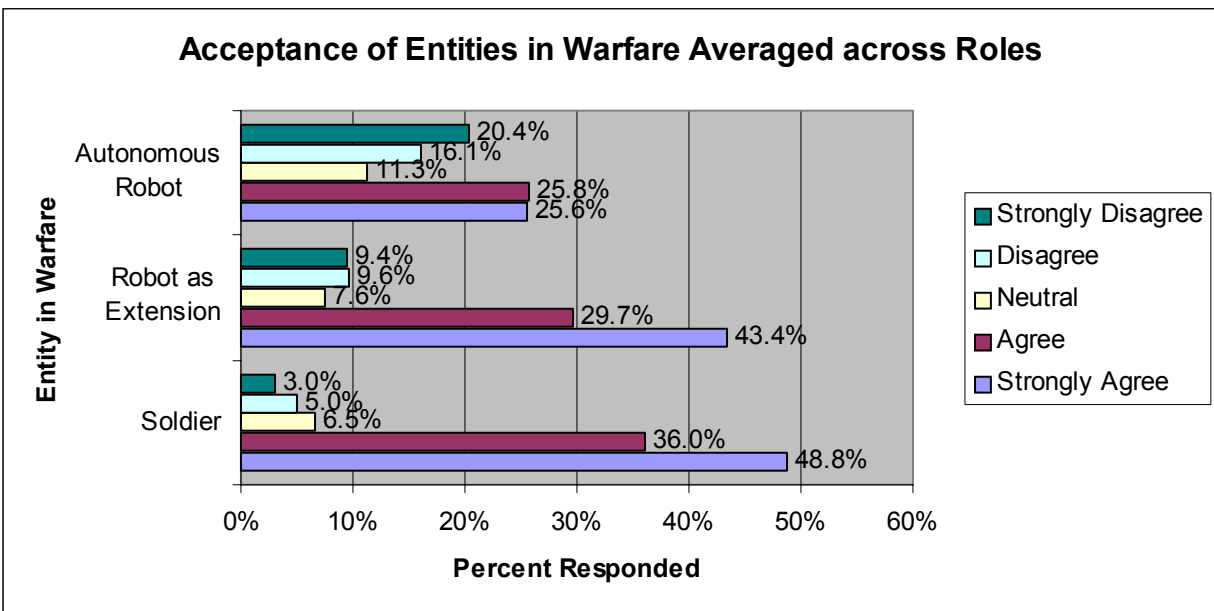
##### 4.1 DEMOGRAPHICS DISTRIBUTION

Demographically, the respondents who completed the survey were distributed as follows:

1. **Gender:** 11% female, 89% male;
2. **Age:** Ranged from 18 years old to over 66, with 43% between 21 and 30 years old, and 22% between 31 and 40;
3. **Education:** 34% and 21%, respectively, have completed or are working/worked towards a postgraduate degree; all others, except for 5% with no higher education, have either completed (21%) or are working/worked towards (18%) their Bachelor’s degree;
4. **Cultural Background:** 55% were raised in the United States, and 45% in other parts of the world;
5. **Policymaking, Military, and Robotics Research Experience:** 30% had military experience, 16% - policymaking experience, and 54% had robotics research experience;
6. **Technology Experience:** The following percentage of the participants had significant or very significant experience with: a) computers: 96%, b) internet: 95%, c) video games: 54%, d) robots: 44%, e) firearms: 29%;
7. **Attitude towards technology and robots:** 95% had a positive or very positive attitude towards technology in general, and 86% towards robots;
8. **Experience with types of robots:** For those participants who significant previous robot experience, hobby robots were the most prevalent, with 88% of participants having had significant experience with them, followed by 85% experience with research robots; 61% had experience with industrial robots, 54% with entertainment robots, 52% with military robots, and less than 50% had significant experience with other types of robots, including service (39%), humanoid (24%), and other (31%);
9. **Media Influence:** Only 21% said that media had a strong or very strong influence on their attitude to robots;
10. **Inevitability of wars:** The majority of participants consider wars either mostly avoidable (32%) or neither avoidable nor inevitable (44%);
11. **Spirituality:** The largest group of participants do not consider themselves spiritual or religious at all (31%), followed by those spiritual to some extent (24%), of significant spirituality (16%), a little (16%), and of very significant spirituality (10%).

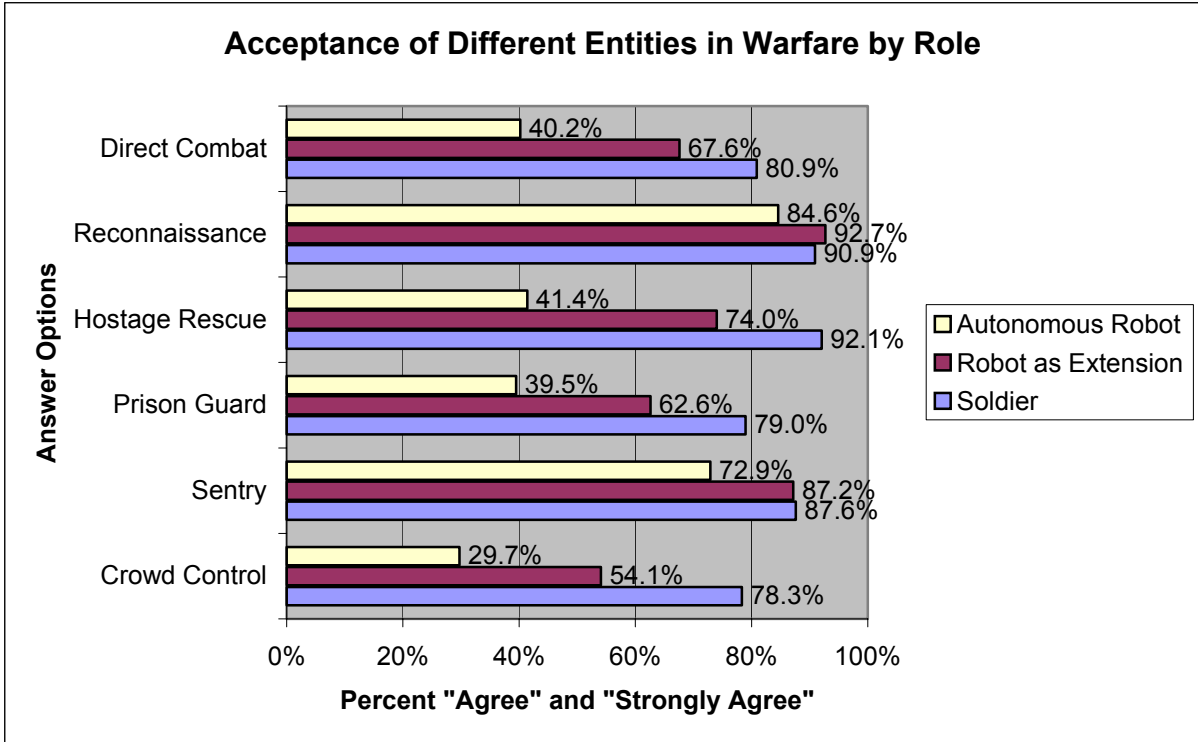
4.2 ROLES SET: QUESTIONS 6-8

As was noted earlier, the human soldier was the entity the most acceptable for most of the warfare roles, with the least amount of disagreement over his/her acceptability. In contrast, the participants were considerably more divided about the acceptability of the autonomous robot, as evidenced by a high number of those who disagreed (16%) or strongly disagreed (20%) with its use (Figure 34). In the case of a robot as an extension, those who agreed or strongly agreed to its use outweighed those who disagreed or strongly disagreed almost to the same extent as in the case of human soldier.

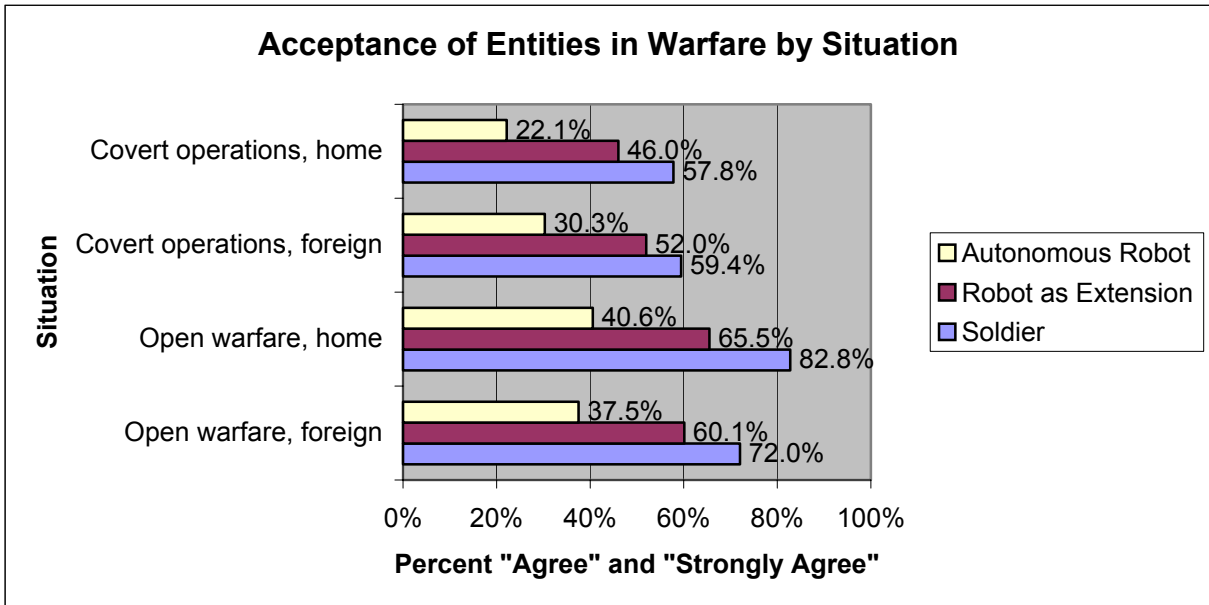


**Figure 34: Levels of Autonomy Averaged across Roles. The opinions were more divided over the acceptability of an autonomous robot.**

It was also noted in the previous section that the difference between acceptance of the three levels of autonomy for Reconnaissance was minimal; it is also fairly small for the role of Sentry, especially in the case of robot as an extension, where both soldier and robot are equally acceptable (87.6% and 87.2% of respondents, respectively, answered “Agree” and “Strongly Agree”; Figure 35). Conversely, the roles of Crowd Control and Hostage Rescue showed the largest total *difference* in acceptance between soldier and autonomous robot (49% and 51% difference, respectively). This suggests that robots could be used for roles where less use of force/lethality is expected, such as Sentry and Reconnaissance, and should be avoided for roles where more force/lethality might be involved, especially with civilians at risk, such as Crowd Control and Hostage Rescue. Appendix C.1 contains additional figures and tables for a more detailed look at the different levels of autonomy within the Roles question.



**Figure 35: Acceptance for Different Levels of Autonomy by Role. All three levels of autonomy are accepted almost equally for Reconnaissance, whereas the roles of Crowd Control and Hostage Rescue show the largest discrepancy in acceptance.**

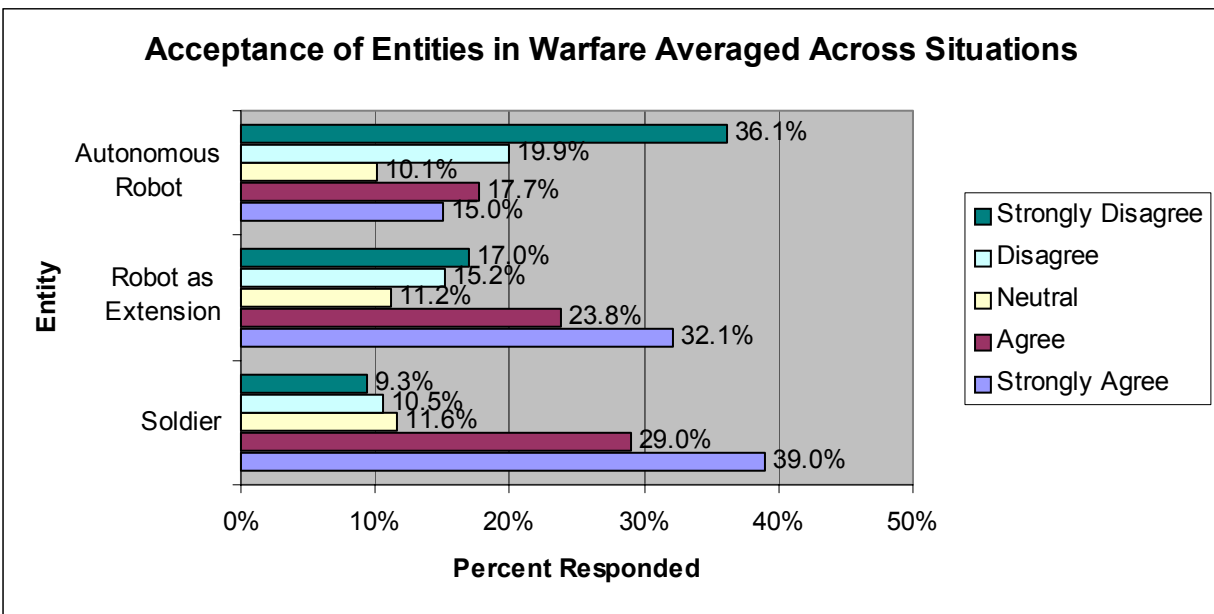


**Figure 36: Acceptance of Entities in Warfare by Situation. Open Warfare on Home Territory is the most accepted situation.**

4.3 SITUATIONS SET: QUESTIONS 9-11

Judging by the data in Figure 36, both a human soldier and a robot as an extension are found to be acceptable to a similar extent in most combat situations (the difference in acceptance ranges from 7% to 12%, with preference given to the human soldier). The difference for Covert Operations on Foreign Territory was the least (7%), suggesting that this may be the most favorable situation to introduce a “robot as an extension” in warfare.

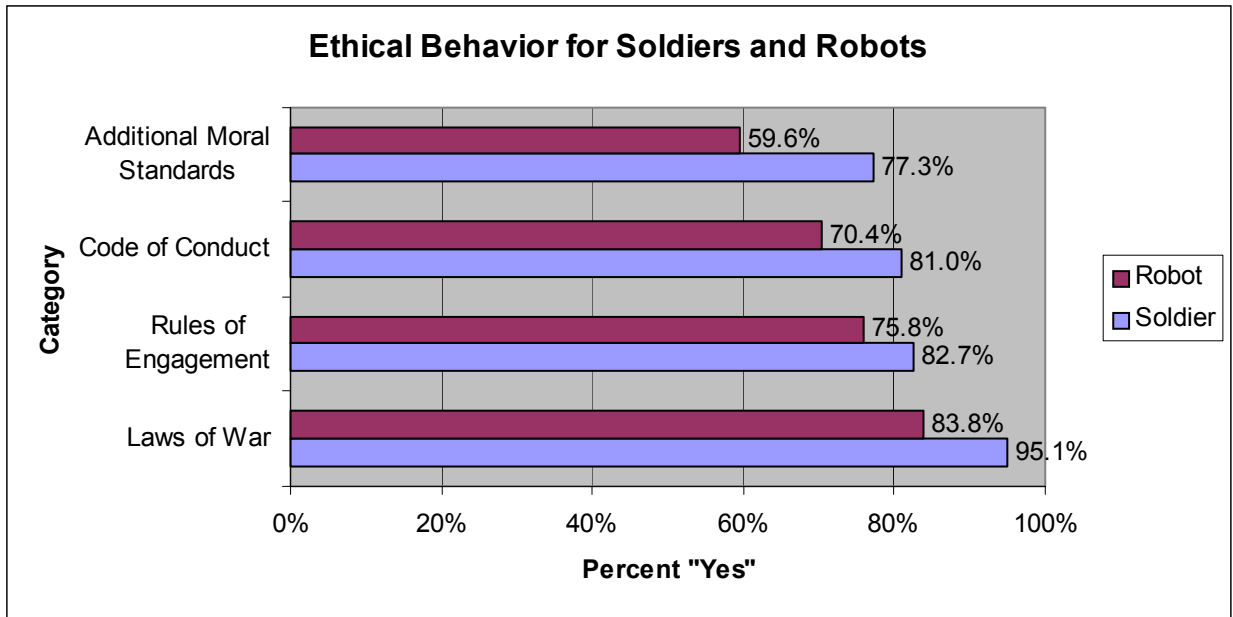
In general across all the situations, the autonomous robot is viewed as largely unacceptable, with over half of the participants (56%) having disagreed or strongly disagreed to its use (Figure 37), especially in the case of Covert Operations on Home Territory (65%, see Appendix C.2 for additional figures). On the other hand, a robot as an extension is much more acceptable than an autonomous robot, with 32% having disagreed or strongly disagreed to its use, and 56% having agreed or strongly agreed.



**Figure 37: Acceptance of Entities in Warfare Averaged Across Situations. Note that autonomous robot is viewed as largely unacceptable.**

4.4 ETHICAL CONSIDERATIONS: QUESTIONS 12-15

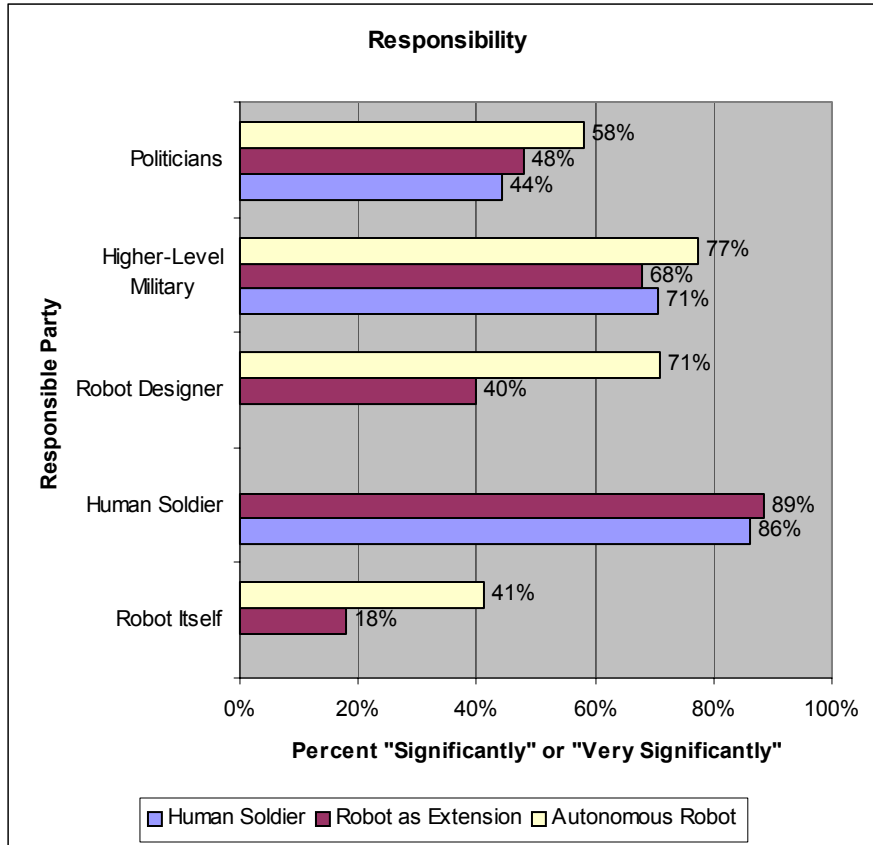
Several possible bases of ethical behavior for soldiers and robots in warfare were presented to the participants, namely: existing laws of ethical conduct of war, such as the Geneva Convention; rules of engagement to guide actions during specific situations in the military; code of conduct which specifies how to behave in general in the military; and additional moral standards. As seen in Figure 38, Laws of War were the most applicable to both soldiers (95% of the participants said “Yes”) and robots (84%), and Additional Moral Standards were the least applicable, with 77% for soldiers and only 60% for robots. One possible explanation for this difference is how specific each of these categories is – in particular, they range from specific and concrete to more general, with Laws of War already available, internationally agreed upon, and easily identifiable, while additional moral standards being much more subject to interpretation and harder to establish or specify.



**Figure 38: Ethical Behavior for Soldiers and Robots. Applicability of ethical categories is ranked from more concrete and specific to more general and subjective.**

*4.5 RESPONSIBILITY: QUESTIONS 16-18*

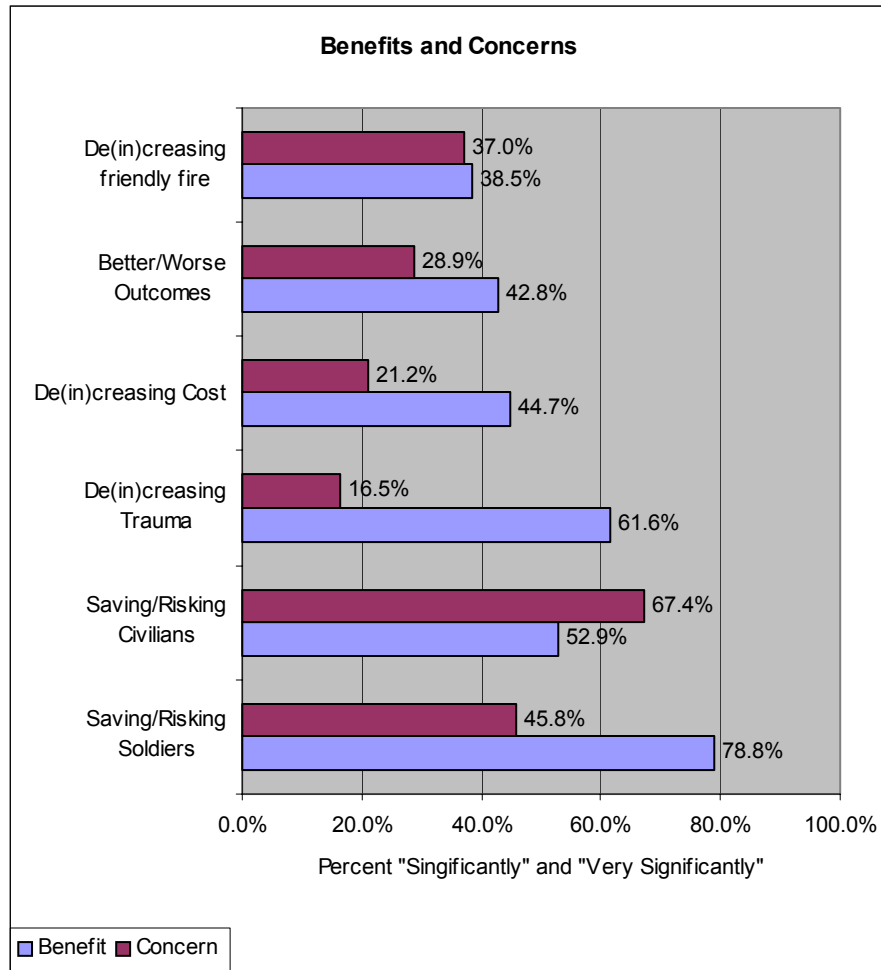
Figure 39 presents an overview of what parties the participants viewed as significantly or very significantly responsible for any lethal mistakes made by entities at each level of autonomy. Overall, the soldier, both by him/herself or while in control of a robot as an extension of the warfighter is viewed as by far the most responsible party (89% and 86%, respectively). This is followed by higher-level military authorities; however, higher-level military are blamed more for the mistakes of an autonomous robot than those of either a soldier or a robot as an extension. The blame assigned to the robot designer differs greatly depending on the robot type, and is almost twice as great in the autonomous robot case, placing the robot designer at the same level as the higher-level military authorities. Only about half of the participants would hold politicians responsible, and, as or the higher-level military and robot designers, politicians were viewed as more responsible for the mistakes of autonomous robot (58% as compared to 44% in the case of soldier). Finally, both a robot as an extension and an autonomous robot were the entities blamed the least for their own errors, with the largest number of participants having answered “Not at All” responsible (60% and 41% respectively, see appendix C.3 for more figures). What the data regarding the autonomous robot suggest is that everyone involved in engaging autonomous robots in warfare is also viewed as responsible to a great extent for its potential lethal mistakes. This corresponds to the finding that in general the participants were unlikely to accept the use of autonomous robots in warfare.



**Figure 39: Responsibility for Lethal Errors by Responsible Party. The soldier was found to be the most responsible party, and robots the least.**

#### 4.6 BENEFITS AND CONCERNS: QUESTIONS 19 AND 20

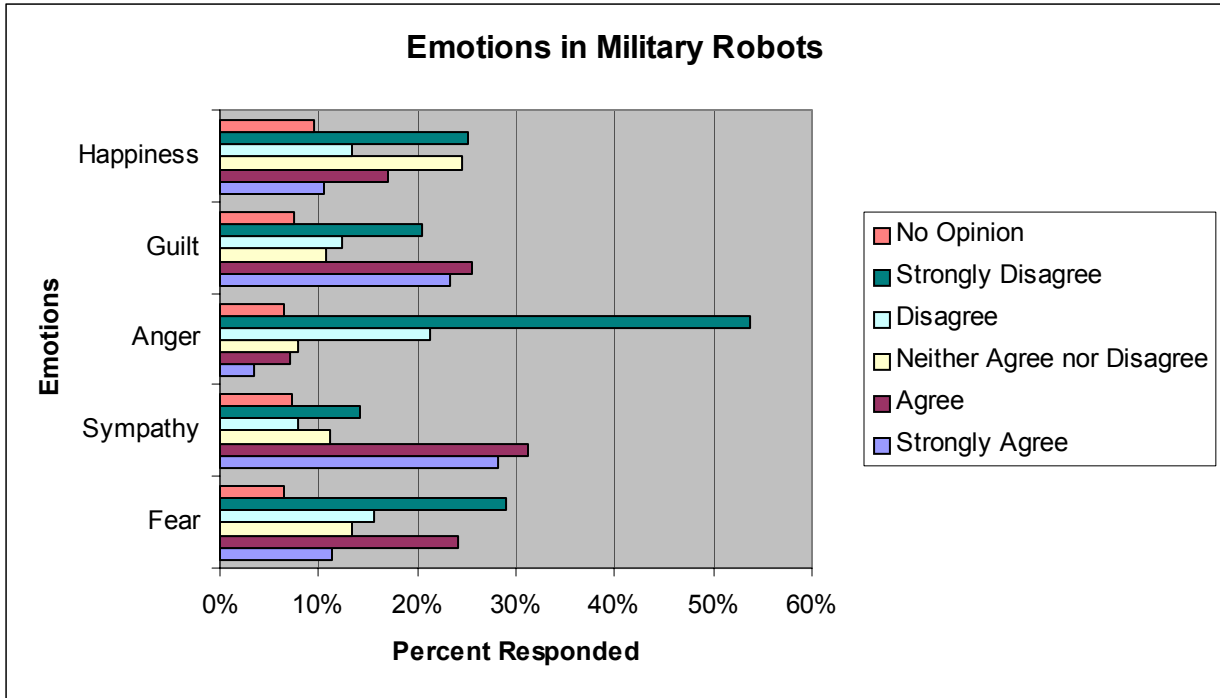
One way to assess benefits of and concerns for employing robots in warfare is by looking at whether certain benefits outweigh concerns, and vice versa (Figure 40). Saving Soldier Lives and Decreasing Psychological Trauma to Soldiers outweigh the potential concerns the most, with 79% and 72% respectively of the participants viewing them as benefits to a significant or very significant extent, as opposed to 46% and 17% of the participants viewing them as a concern. Decreasing Cost and Producing Better Battlefield Outcomes were other two categories viewed as benefits rather than concerns to some extent. The participants were largely undecided as to whether a robot presence would increase or decrease friendly fire, resulting in almost equal number of respondents identifying this category as both a benefit and a concern (39% and 37% respectively). Finally, the presence of robots in the battlefield is viewed as more of a concern for a potential risk of civilian lives (67%), rather than a benefit of saving them (53%). The latter finding may help explain the low acceptance of autonomous robots of the roles of Crowd Control and Hostage Rescue, both of which involve potential use of force and lethality while in contact with non-combatants, which many participants believe, it seems, may be risky for civilians.



**Figure 40: Benefits of and Concerns for Using Robots in Warfare. Saving Soldier Lives and Decreasing Soldier Trauma outweighed the corresponding concerns the most, and Risking Civilian Lives was considered more of a concern than Saving Civilian Lives as a benefit.**

*4.7 WARS AND EMOTIONS: QUESTIONS 21 AND 22*

The participants seem to have found the question regarding emotions in a military robot hard to answer, as evidenced by a high percentage of those who chose “No Opinion/Don’t Know” option (7.5% on average). Those who answered otherwise seem to be divided in their opinions. For example, there were almost as many of those who believed that fear can be beneficial for a military robot (36%) as those who disagreed (45%). The two exceptions to this were the emotions of sympathy (59% agreed or strongly agreed that sympathy may be beneficial) and anger (75% disagreed or strongly disagreed). More detail on the opinion distribution for the Emotions question can be found in Figure 41.



**Figure 41: Emotions in Military Robots.**

4.8 SUMMARY OF DETAILED ANALYSIS

The findings in this section can be summarized as follows:

- Taking human life by autonomous robot in both Open Warfare and Covert Operations is unacceptable to more than half of the participants (56% disagreed or strongly disagreed), especially in the case of Covert Operations on Home Territory.
- Robots could be acceptably used for roles where less force is involved, such as Sentry and Reconnaissance, and should be avoided for roles where the use of force may be necessary, especially when civilian lives are at stake such as Crowd Control and Hostage Rescue.
- The more concrete, specific, and identifiable ethical standards were, the more likely they were to be considered applicable to both soldiers and robots, with Laws of War being the most applicable, and Additional Moral Standards the least.
- A soldier was the party considered the most responsible for both his/her own lethal errors and those of a robot as an extension under his/her control. Robots were the least blamed parties, although an autonomous robot was found responsible for erroneous lethal action twice as much as the robot as an extension of the warfighter.
- Saving soldiers' lives and decreasing psychological trauma to soldiers outweigh the risk to the soldiers the most. Decreasing cost and producing better battlefield outcomes were also viewed as benefits rather than concerns.



## 5. ROBOTICS RESEARCHER DATA ANALYSIS

This section presents the rigorous statistical analysis results specifically for the robotics researcher community type, the largest demographic community available, including the demographics data for this type. Comparisons based on a number of demographic variables are made where appropriate. In particular, we compared those respondents who were raised in the USA to those raised elsewhere (cultural background); those of very significant, significant or some spirituality to those who are a little or not at all religious/spiritual (spirituality); and those with very significant, significant or some experience with firearms relative to those with little or no experience (firearms experience).

### 5.1 DEMOGRAPHICS DISTRIBUTION

Demographically, the robotics researchers were distributed as follows:

- 1) **Gender:** 11% female, 89% male;
- 2) **Age:** Ranged from 18 years old to over 66, with 46% between 21 and 30 years old, and 23% between 31 and 40;
- 3) **Education:** 41% and 23%, respectively, have completed or are working/worked towards a postgraduate degree; all others, except for 4% with no higher education, have either completed (18%) or are working/worked towards (17%) their Bachelor's degree;
- 4) **Cultural Background:** 52% were raised in the United States, and 48% in other parts of the world;
- 5) **Policymaking and Military Experience:** 27% of robotics researchers also had military experience, and 16% policymaking experience;
- 6) **Technology Experience:** The following percentage of the participants had significant or very significant experience with: a) computers: 99%, b) internet: 99%, c) video games: 54%, d) robots: 75%, e) firearms: 33%;
- 7) **Attitude towards technology and robots:** 98% had a positive or very positive attitude towards technology in general, and 93% towards robots;
- 8) **Experience with types of robots:** Research robots were the most prevalent, with 78% of participants having had significant experience with them, followed by 63% experience with hobby robots; less than 50% had significant experience with other types of robots, including industrial (46%), military (45%), entertainment (36%), service (32%), humanoid (22%), and other (23%);
- 9) **Media Influence:** Only 18% said that media had a strong or very strong influence on their attitude to robots;
- 10) **Inevitability of wars:** The majority of participants consider wars either mostly avoidable (36%) or neither avoidable nor inevitable (43%);
- 11) **Spirituality:** The largest group of participants do not consider themselves spiritual or religious at all (32%), followed by those spiritual to some extent (23%), of significant spirituality (15%), a little (17%), and of very significant spirituality (11%).

## 5.2 ROLES AND SITUATIONS

As mentioned earlier, the order of the questions in Roles and Situations sets of questions was counterbalanced. In version A, the questions regarding the human soldier were presented first, followed by the robot as an extension, followed by the autonomous robot. This order was reversed in version B. To check for any order effects, 2 (order) x 6 (roles) mixed ANOVAs were done on each question in the Roles set, and 2 (order) x 4 (situations) mixed ANOVAs were done on each question in the Situations set. There was no order effect on the answers, as was evidenced by  $p$  greater than at least 0.18 for each of the questions.

### 5.2.1 Roles Set: Questions 6-8

To analyze this set of questions, a 2 (Cultural Background) x 3 (Level of Autonomy) x 6 (Role) mixed ANOVA was performed. The findings can be summarized as follows:

- The roboticist participants preferred employing a human soldier over a robot as an extension over an autonomous robot both overall, and for each separate role (with the exception of the roles of Sentry and Reconnaissance, where there was no significant difference between human soldier and robot as an extension). The mean ( $M$ ) for human soldier was 1.8 (between “Strongly Agree” and “Agree”) and Standard Error ( $SE$ ) was 0.05; for robot as an extension  $M=2.1$  (between “Agree” and “Neutral”) and  $SE=0.06$ ; and for autonomous robot  $M=2.8$  (between “Agree” and “Neutral”, but significantly closer to “Neutral”) and  $SE=0.07$ . This ranking was preserved for most of the roles, except that of Sentry (there was no difference between human soldier and robot as an extension) and that of Reconnaissance, for which the robot as an extension was the most acceptable entity, and soldier and autonomous robot were equally acceptable. This finding is consistent with the previous qualitative analysis and suggests that, in general, the more control shifts away from the human to the robot, the less such a robot is acceptable to the respondents, with the exception of Reconnaissance, where the robots are equally or even more acceptable than humans.
- The least acceptable role for use of either human soldiers or robots was Crowd Control ( $M=2.7$ ,  $SE=0.07$ ), followed by equally rated roles of Direct Combat ( $M=2.5$ ,  $SE=0.07$ ) and Prison Guard ( $M=2.5$ ,  $SE=0.07$ ), followed by Hostage Rescue ( $M=2.1$ ,  $SE=0.06$ ), Sentry ( $M=1.9$ ,  $SE=0.06$ ) and Reconnaissance ( $M=1.6$ ,  $SE=0.05$ ), with the latter being by far the most preferred role. This ranking was preserved for a robot as an extension of the warfighter, but was slightly different for the human soldier (there was no significant difference in preference between Hostage Rescue and Reconnaissance) and autonomous robot (there was no significant difference between Prison Guard and Hostage Rescue, but Prison Guard was slightly preferred over Direct Combat).
- Overall, those roboticist participants who were raised in the United States found it more acceptable to employ any of the above entities for these roles ( $M(US)= 1.9$ ,  $SE(US)=0.07$ ,  $M(non-US)=2.5$ ,  $SE(non-US)=0.07$ ). This difference in opinions held for each level of autonomy as well.

Additionally, a 2 (Spirituality) x 3 (Level of Autonomy) x 6 (Role) mixed ANOVA was performed. Those of higher spirituality found, on average, the entities potentially employed in warfare more acceptable than those who are less religious/spiritual (main effect of Spirituality:  $M(S)=2.1$ ,  $SE=0.07$ ,  $M(\text{non-S})=2.3$ ,  $SE=0.08$ ,  $p<0.018$ ). This effect did not hold for a human soldier or an autonomous robot ( $p<0.06$ ), but held for the robot as an extension ( $p<0.017$ ).

Finally, a 2 (Firearms Experience) x 3 (Level of Autonomy) x 6 (Role) mixed ANOVA was performed. Those with more firearms experience found, on average, the entities potentially employed in warfare more acceptable than those with less experience (main effect of Firearms:  $M(F)=2.1$ ,  $SE=0.07$ ,  $M(\text{non-S})=2.3$ ,  $SE=0.08$ ,  $p<0.025$ ). This effect didn't hold for human soldier, but held for the autonomous robot ( $p<0.015$ ), and robot as an extension ( $p<0.016$ ).

### 5.2.2 Situations Set: Questions 9-11

As with the Roles set, this question was repeated for a robot as an extension and an autonomous robot. To analyze this set, a 2 (Cultural Background) x 3 (Level of Autonomy) x 4 (Situation) mixed ANOVA was performed. The summary of findings is presented below:

- As with the previous set, the participants found the human soldier to be the most acceptable entity to be employed overall ( $M=2.3$ ,  $SE=0.07$ ), followed by robot as an extension ( $M=2.7$ ,  $SE=0.08$ ), while an autonomous robot was deemed the least acceptable ( $M=3.5$ , between “Neutral” and “Disagree”;  $SE=0.09$ ). This trend was also preserved for each of the situations (both the main effect of autonomy, and simple main effects of autonomy for each situation were statistically significant at  $p=0.0001$ ).
- “Open war on home territory” was the most accepted situation overall ( $M=2.5$ ,  $SE=0.07$ ), followed by “Open war on foreign territory” ( $M=2.8$ ,  $SE=0.08$ ), with both “Covert Operations” situations being the least acceptable with  $M=3.0$ ,  $SE=0.08$  for “Foreign Territory” and  $M=3.1$ ,  $SE=0.09$  for “Home Territory”. The same trend was preserved for both robot as extension and autonomous robot, but in the case of human soldier there was no significant difference between the covert operations situations.
- Similar to the previous set, US participants found it more acceptable in general to employ either human soldiers or robots in these situations ( $M(\text{US}) = 2.4$ ,  $SE=0.1$  and  $M(\text{non-US}) = 3.3$ ,  $SE=0.1$ ), as well as for each level of autonomy.

Additionally, a 2 (Spirituality) x 3 (Level of Autonomy) x 6 (Role) mixed ANOVA was performed. Those of higher spirituality found, on average, the entities potentially employed in warfare more acceptable than those less religious/spiritual (main effect of Spirituality:  $M(S)=2.5$ ,  $SE=0.1$ ,  $M(\text{non-S})=3.1$ ,  $SE=0.1$ ,  $p<0.001$ ). This effect also held for each level of autonomy ( $p<0.001$ ).

Finally, a 2 (Firearms Experience) x 3 (Level of Autonomy) x 6 (Role) mixed ANOVA was performed. Those with more firearms experience found, on average, the entities potentially employed in warfare more acceptable than those with less experience (main effect of Firearms:  $M(F)=2.4$ ,  $SE=0.1$ ,  $M(\text{non-S})=3.3$ ,  $SE=0.1$ ,  $p<0.001$ ). This effect also held for each level of autonomy ( $p<0.001$ ).

### 5.3 ETHICAL CONSIDERATIONS: QUESTIONS 12-15

Questions 12 and 13 were not suitable for statistical analysis, as the answer choice was limited to Yes, No, and No Opinion.

#### **Higher, Same or Lower Ethical Standards for Robots (Question 14)**

One-way ANOVAs were performed to assess whether there was any difference between those of different cultural background, spirituality and firearms experience in terms of what ethical standards they believe an autonomous robot should adhere to. The answer options for this question were as follows: 1 for “Higher than soldier”, 2 for “Same” and 3 for “Lower”. There was a significant difference between those raised in the US ( $M(\text{US})=1.42$ ,  $M(\text{non-US}) = 1.27$ ,  $p<0.016$ ), suggesting that non-US participants were more likely than those raised in the US to hold robots to higher ethical standards than those of a soldier. Those who had less experience with firearms were also more likely to hold robots to more stringent ethical standards than those with greater firearms experience ( $M(\text{firearms}) = 1.45$ ,  $M(\text{non-firearms}) = 1.25$ ,  $p<0.003$ ). Finally, no difference with regards to this question was found among those of different spirituality.

#### **Refusal of an Unethical Order (Question 15)**

Similarly, one-way ANOVAs with regards to cultural background, spirituality and firearms experience were performed on the question regarding a robot’s refusal of an unethical order given by a human. The answer options for this question ranged from “Strongly Agree” (1) to “Strongly Disagree” (5). The US participants as well as those with more firearms experience were less likely to give a robot such a right to refuse an unethical order ( $M(\text{US}) = 3$ ,  $M(\text{non-US}) = 2.29$ ),  $p<0.001$ ;  $M(\text{firearms}) = 2.8$ ,  $M(\text{non-firearms}) = 2.4$ ,  $p<0.023$ ); there was no significant difference based on spirituality.

### 5.4 RESPONSIBILITY: QUESTIONS 16-18

As in the case of Roles and Situations sets of questions, the order of Responsibility questions was counterbalanced. In version A, the questions regarding the human soldier were presented first, followed by the robot as an extension, followed by the autonomous robot; this order was reversed in version B. The answer options for this set of questions ranged from “Very Significantly” (1) to “Not at All” (5). To check for any order effects, 2 (order) x 3 (responsible parties for soldier), 2 (order) x 5 (responsible parties for robot as an extension), and 2 (order) x 4 (responsible parties for autonomous robot) mixed ANOVAs were performed. There was no order effect on the answers, as was evidenced by  $p$  greater than at least 0.06 for each of the questions.

For each of the levels of autonomy, 3 mixed ANOVAs were performed: (level of autonomy) x (responsible party) x (cultural background), (level of autonomy) x (responsible party) x (spirituality), and (level of autonomy) x (responsible party) x (firearms experience). The findings for **human soldier** can be summarized as follows:

- The extent to which each responsible party was blamed differed significantly ( $p<0.001$ ), where the soldier was responsible for his/her mistakes the most ( $M=1.54$ ), followed by higher-level military authorities ( $M=2.05$ ); finally, the politicians were considered the least responsible ( $M=2.71$ ).

- There was a significant main effect of cultural background, with US participants less likely to find any of the parties as responsible for soldier's mistakes when compared to the non-US respondents ( $M(\text{US}) = 2.33$ ,  $M(\text{non-US}) = 1.86$ ,  $p < 0.001$ ).
- There was a significant main effect of firearms experience, with those more experienced being less likely to blame any of the parties ( $M(\text{firearms}) = 2.28$ ,  $M(\text{non-firearms}) = 1.92$ ,  $p < 0.001$ ).
- No significant effect was observed for spirituality.

Similar results were observed for **robot as an extension**:

- The responsible parties differed significantly in the extent to which they were blamed for the lethal errors of robot as an extension ( $p < 0.001$ ). A soldier in control was blamed by far the most ( $M = 1.56$ ), followed by higher-level military authorities ( $M = 2.2$ ). Politicians and robot designers were deemed less responsible ( $M = 2.7$  and  $M = 2.9$ , respectively), but still between "Significantly" and "Somewhat". Finally, the robot as an extension itself was found the least responsible for its errors ( $M = 4$ ).
- US participants were less likely to blame any of the responsible parties overall ( $M(\text{US}) = 3$ ),  $M(\text{non-US}) = 2.4$ ,  $p < 0.001$ ), although there was no significant difference in the extent of responsibility they assigned to the soldier in control of robot as an extension.
- Similarly, those with more significant firearms experience were less willing to assign responsibility to any of the proposed parties ( $M(\text{firearms}) = 2.9$ ,  $M(\text{non-firearms}) = 2.5$ ,  $p < 0.001$ ), although there was no significant difference in responsibility assigned to both a robot and a soldier in control.
- No significant effect was observed for spirituality.

Finally, the following results were obtained for the **autonomous robot**:

- The responsible parties differed significantly in the extent to which they were blamed for the lethal errors of an autonomous robot ( $p < 0.001$ ). The party deemed the most responsible was higher-level military ( $M = 1.8$ ), followed by robot designer ( $M = 2$ ) and politicians ( $M = 2.4$ ). Please note that the level of responsibility attributed to robot designers and politicians was reversed in this ranking when compared to the case of robot as an extension. Finally, the robot itself was still the least blameworthy party ( $M = 3.3$ ).
- US participants were less likely to blame any of the responsible parties overall ( $M(\text{US}) = 2.5$ ),  $M(\text{non-US}) = 2.2$ ,  $p < 0.001$ ), although there was no significant difference in the extent of responsibility they assigned to the autonomous robot.
- No significant effects were observed for spirituality or firearms experience.

### 5.5 BENEFITS AND CONCERNS: QUESTIONS: QUESTIONS 19 AND 20

In order to determine which benefits and concerns were the most prominent, 2 one-way ANOVAs were performed, one for benefits, and one for concerns.

#### **Benefits Comparison**

Saving lives of soldiers was the benefit agreed on the most by the participants (M=1.9, SE=0.09). The participants were not as clear in their opinions on the rest of the benefits. Three of the total roboticist responses averaged between Agree and Neutral, closer to Neutral: Saving Civilian Lives (M=2.6, SE=0.1), Decreasing Trauma to Soldiers (M=2.4, SE=0.09), and Producing Better Outcomes (M=2.9, SE=0.1). Finally, the participants were undecided on whether to consider Decreasing Cost (M=3, SE=0.1) and Decreasing Friendly Fire (M=3.1, SE=0.1) as benefits.

#### **Concerns Comparison**

Risking civilian lives was the concern agreed upon the most (M=2.1, SE=0.08); and only two other categories were thought of as concerns: Risking Lives of Soldiers (M=2.7, SE=0.09) and Increasing Friendly Fire (M=2.8, SE=0.09). The participants were more ambivalent regarding considering Producing Worse Outcomes (M=3.2, SE=0.1), Increasing Cost (M=3.6, SE=0.1) and Increasing Trauma (M=3.8, SE=0.09) as concerns, leaning more towards “Disagree” on the latter two categories. Overall, the categories regarding battlefield outcomes and friendly fire were not considered strongly as either benefits or concerns, suggesting that the participants didn’t think that robots would have much of an effect on these categories.

#### **Benefits vs. Concerns**

To determine whether benefits outweighed concerns, 6 one-way ANOVAs were performed, one per each benefit/concern pair. For the following categories, benefits outweighed concerns: Saving Lives of Soldiers (M(B)=1.8, SE(B)=0.08, M(C)=2.6, SE=(0.09),  $p<0.001$ ); Reducing Trauma (M(B)=2.4, SE(B)=0.09, M(C)=3.8, SE=(0.09),  $p<0.001$ ); Decreasing Cost (M(B)=3.0, SE(B)=0.1, M(C)=3.6, SE=(0.1),  $p<0.001$ ); and Producing Better Outcomes (M(B)=2.8, SE(B)=0.1, M(C)=3.2, SE=(0.09),  $p<0.009$ ). This finding therefore provides incentives for using robots in warfare. For Risking Civilian Lives (M(B)=2.6, SE(B)=0.1, M(C)=2, SE=(0.08),  $p<0.001$ ) and Increasing Friendly Fire (M(B)=3.2, SE(B)=0.1, M(C)=2.8, SE=(0.09),  $p<0.007$ ), concerns outweighed the benefits, this perception should be also taken into consideration when considering robot deployment in areas populated with noncombatants, and situations in which occurrences of friendly fire are more likely.

### 5.6 WARS AND EMOTIONS

#### **Wars**

One-way ANOVAs were performed to assess whether there was any difference between those of different cultural background, spirituality and firearms experience regarding their opinion on how easy it would be to start wars with robots as participants. The answer options for this question ranged from “Much Harder” (1) to “Much Easier” (5). Those raised in the US were less convinced that it would be easier to start wars if robots were brought onto the battlefield than

those raised elsewhere (M(US)=3.8, SE(US)=0.09, M(non-US)=4.3, SE(non-US)=0.09,  $p<0.001$ ). The same trend was observed for those more spiritual (M=3.9, SE=0.1) vs. less spiritual (M=4.2, SE=0.09,  $p<0.01$ ), and those with more firearms experience (M=3.9, SE=0.09) vs. those with less experience (M=4.2, SE=0.1,  $p<0.023$ ).

### **Emotions**

One-way repeated measures ANOVA was performed on the emotions question. All emotions were significantly different from each other, except for Fear and Happiness, on which participants' opinions were equally neutral (M(F) = 3.2, M(H)=3.3,  $p<0.5$ ). Sympathy was most likely to be found beneficial in a military robot (M(S)=2.5), followed by Guilt (M(G)=2.8. Anger was the emotion the participants disagreed with the most (M(A)=4.2).

3 6(emotion) x 2 (cultural background/spirituality/firearms experience) ANOVAs were performed on the emotions question (where the answer options ranged from "Strongly Agree" (1) to "Strongly Disagree" (5)). The findings are summarized below:

- In general, those raised in the US were less in favor of emotions in military robots (M(US)=3.4, SE(US)=0.1, M(non-US)=3, SE(non-US)=0.1,  $p<0.014$ ), but this effect held only for Sympathy, Guilt and Fear.
- Similarly, those with more firearms experience found emotions in general less beneficial to a military robot than those with less experience (M(firearms)=3.4, SE=0.1, M(non-firearms)=3,  $p<0.01$ ). This effect also held for Sympathy, Guilt and Happiness.
- Finally, there was no effect of spirituality on the participants' opinions on emotions.

### *5.7 SUMMARY: ROBOTICS RESEARCHER ANALYSIS*

Statistical analysis performed on the robotics researcher community type was consistent, where comparable, with the findings from the previous qualitative analysis. Additionally, it was observed that the categories regarding battlefield outcomes and friendly fire were not considered strongly as either benefits or concerns, suggesting that the participants didn't think that robots would have much of an effect on these categories.

The differences in responses due to cultural background, spirituality and firearms experience are summarized below:

- US participants were more likely to accept both soldiers and robots in proposed roles and situations than non-US participants. They favored less stringent ethical standards for robots and were less likely to give robot a right to refuse an unethical order than non-US participants. They were also less likely to assign responsibility for lethal errors of soldiers and robots and less willing to provide military robots with emotions.
- Those with less firearms experience found the use of all three levels of autonomy for the proposed roles less acceptable overall than those with more experience, and found the use of both types of robots less acceptable in the proposed situations. They were also more likely to hold robots to more stringent ethical standards, as compared to those of a soldier; more likely to allow the robot to refuse an unethical order, more

prone to assign responsibility for lethal errors of soldier and robot as extension, and more willing to provide military robots with the emotions of Sympathy, Guilt and Happiness.

- In most cases, the level of spirituality had no effect on the participant's opinions, with the exception of the use of robot as an extension of the warfighter for the proposed roles and the use of all three levels of autonomy in the proposed combat situations, where those of higher spirituality found such use more acceptable in warfare. Also, more spiritual/religious participants were less convinced that it would be easier to start wars if robots were brought onto the battlefield.



## **6. CONCLUSIONS**

After analyzing the results of the survey, the following generalizations can be made:

### **Demographics:**

- A typical respondent was an American or Western European male in his 20s or 30s, with higher education, significant computer experience, and positive attitude toward technology and robots.
- The participants ranged from under 21 to over 66 years old (all the participants were over 18); 11% of the participants were female; non-US participants were from all over the world, including Australia, Asia, Eastern Europe and Africa.

### **Levels of Autonomy:**

- In general, regardless of roles or situations, the more the control shifts away from the human, the less such an entity is acceptable to the participants. A human soldier was the most acceptable entity in warfare, followed by the robot as an extension of the warfighter, and autonomous robot was the least acceptable (see sections 3.1.1, 4.2, 4.3).
- There was a larger gap in terms of acceptability between a robot as an extension and autonomous robot than that between soldier and robot as an extension (see sections 3.1.1, 4.2, 4.3).
- Taking human life by an autonomous robot in both Open Warfare and Covert Operations is unacceptable to more than half of the participants (56% disagreed or strongly disagreed), especially in the case of Covert Operations on Home Territory (see section 4.3).

### **Comparison between Community Types:**

- Regardless of roles or situations, in most cases the general public found the employment of soldiers and robots less acceptable than any other community type, and, conversely, those with military experience and policymakers found such employment more acceptable (section 3.1.1).
- More military and policymakers were in favor of the same ethical standards for both soldiers and robots than both the general public and roboticists, who were more in favor of higher standards for robots (section 3.2).
- When asked about the responsibility for any lethal errors, those with military experience attributed the least amount of blame to any of the responsible parties (section 3.3).

### **Roles:**

- The most acceptable role for using both types of robots is Reconnaissance; the least acceptable is Crowd Control (section 3.1.1).

- Robots could be used for roles where less force is involved, such as Sentry and Reconnaissance, and should be avoided for roles where use of force may be necessary, especially when civilian lives are at stake, such as Crowd Control and Hostage Rescue (section 3.1.1).

**Situations:**

- Covert Operations were less acceptable to the entire set of participants than Open Warfare (whether on Home or Foreign Territory; section 3.1.1).

**Ethical Considerations:**

- The majority of participants, regardless of the community type, agreed that the ethical standards, namely, Laws of War, Rules of Engagement, Code of Conduct and Additional Moral Standards, do apply to both soldiers (84%) and robots (72%); section 3.2.
- The more concrete, specific and identifiable ethical standards were, the more likely they were to be considered applicable to both soldiers and robots, with Laws of War being the most applicable, and Additional Moral Standards the least (section 4.4).
- 66% of the participants were in favor of higher ethical standards for a robot than those for a soldier (section 4.4).
- 59% of the participants believed that an autonomous robot should have a right to refuse an order it finds unethical, thus in a sense admitting that it may be more important for a robot to behave ethically than to stay under the control of a human (section 3.2).

**Responsibility:**

- A soldier was the party considered the most responsible for both his/her own lethal errors, and for those of a robot as an extension under his/her control. Robots were the least blamed parties, although an autonomous robot was found blameworthy twice as much as robot as an extension (sections 3.3, 4.5). It is interesting that even though robots were blamed the least, 40% of the respondents still found an autonomous robot responsible for its errors to a very significant or significant extent.
- As the control shifts away from the soldier, the robot and its maker should take more responsibility for robot's actions. A robot designer was blamed 31% less for the mistakes of a robot as an extension than those of an autonomous robot (section 3.3).

**Benefits and Concerns:**

- Saving lives of soldiers was considered the most clear-cut benefit of employing robots in warfare and the main concern was that of risking civilian lives (section 4.6).
- Saving soldiers' lives and decreasing psychological trauma to soldiers outweigh the risk to the soldiers the most. Decreasing cost and producing better battlefield outcomes were also viewed as benefits rather than concerns (section 4.6).

- For the roboticists, the categories regarding battlefield outcomes and friendly fire were not considered strongly as either benefits or concerns, suggesting that the participants did not think that robots would have an effect on these categories.

#### **Wars and Emotions:**

- The majority of the participants (69%) believe that it would be easier to start wars if robots were employed in warfare (section 3.5).
- Sympathy was considered to be beneficial to a military robot by over half of the participants (59%), and guilt by just under a half (49%). The majority of the participants (75%) were against anger in a military robot (sections 3.5 and 4.7).

#### **Cultural Background:**

- US participants were more likely to accept both soldiers and robots in proposed roles and situations than non-US participants. They favored less stringent ethical standards for robots and were less likely to give the robot a right to refuse an unethical order than non-US participants. They were also less likely to assign responsibility for lethal errors of soldiers and robots and less willing to provide military robots with emotions (section 5).

#### **Firearms Experience:**

- Those with less firearms experience found the use of all three levels of autonomy for the proposed roles, overall, less acceptable than those with more experience, and found the use of both types of robots less acceptable in the proposed situations (section 5.1).
- Those with less firearm experience were also more likely to hold a robot to more stringent ethical standards when compared to those of a soldier; more likely to allow a robot to refuse an unethical order, more prone to assign responsibility for lethal errors of soldier and robot as extension, and more willing to provide military robots with the emotions of sympathy, guilt and happiness (section 5).

#### **Spirituality:**

- In most cases, spirituality had no effect on the participants' opinions with the exception of the use of robot as an extension for the proposed roles and the use of all three levels of autonomy in the given situations. Those of higher spirituality found such use more acceptable in warfare; also, more spiritual/religious participants were less convinced that it would be easier to start wars if robots were brought onto the battlefield.

## 7. REFERENCES

- [1] Foster-Miller Inc., “Products & Service: TALON Military Robots, EOD, SWORDS, and Hazmat Robots”, 2007.
- [2] “Reaper moniker given to MQ-9 Unmanned Aerial Vehicle”, Official Website of the United States Air Force, 2006.
- [3] Opall-Rome, B., “Israel Wants Robotic Guns, Missiles to Guard Gaza”, *Defensenews.com*, 2007.
- [4] Kumagai, J., “A Robotic Sentry for Korea’s Demilitarized Zone”, *IEEE Spectrum*, March 2007.
- [5] Arkin, R.C., “Governing Lethal Behavior: Embedding Ethics in a Hybrid Deliberative/Reactive Robot Architecture”, *GVU Technical Report GIT-GVU-07-11*, 2007.
- [6] Arkin, R.C. and Moshkina, L., “Lethality and Autonomous Robots: An Ethical Stance”, *Proc. IEEE International Symposium on Technology and Society*, Las Vegas, NV, June 2007.
- [7] Punch, K.F., *Survey Research: The Basics*, Sage Publications, 2003.
- [8] Dillman, D.A., *Mail and Internet Surveys: The Tailored Design Method*, John Wiley & Sons, Inc., Hoboken, NJ, 2007.
- [9] Best, S.J., Krueger, B.S., *Internet Data Collection*, Sage Publications, 2004.  
function networks,” *IEEE Trans. Neural Networks*, vol. 4, pp. 570–578, July 1993

## APPENDIX A: QUESTIONNAIRE SCREENSHOTS

The survey was fully administered online, and the following screenshots are organized by page on which they appeared. In most cases, the questions were grouped together on a page thematically.

**Page 1: Introductory Page.** The screenshot below Shows how the survey was displayed online, with the title in the top left corner, the “Exit this survey” link in the top right corner, and “Next>>” button to navigate to the next page in the survey. All the consequent pages of the survey had the same general layout; additionally, each page had “<<Prev” button to go to the previous page, and if not all the content was visible on the screen at once, a scroll bar was display to navigate the page.

1. Title of Research Project  
Survey on the Use of Robots Capable of Lethal Force in Warfare

2. Principal Investigator  
Ronald C. Arkin

3. Purpose of Research  
You are being asked to volunteer to complete a survey asking your opinions on the use of robots capable of lethal force in warfare. By analyzing these opinions, we hope to find out how acceptable such robots are to the public. This survey is sponsored by the Army Research Office.

4. Procedure  
You are asked to complete a survey asking your opinions on the use of robots capable of lethal force in warfare. This survey will be fully web-based, and no paper or direct interaction with others will be required. Your time commitment should not exceed 30 minutes.

5. Foreseeable risks or discomforts:  
This research involves minimal risk, similar to that involved in any everyday activity, for example, reading your e-mail. However, some people may experience slight discomfort discussing the issues of using lethal force.

6. Benefits  
Although there are no direct benefits to you, your opinions may possibly help shape both future robotics research and potential policy that will govern the use of lethal robots in the military.

7. Compensation/Costs  
Neither costs nor compensation are involved with this survey.

**Screenshot 1: Introductory page to the survey.**

**Page 2: Consent Form.** The participants had to select “I Agree” or “I Do Not Agree” radio button in order to move on with the survey. Selecting “I Do Not Agree” resulted in the following message: “Thank you for looking at the survey. Sorry you couldn't complete it.”

1. Title of Research Project  
Survey on the Use of Robots Capable of Lethal Force in Warfare

2. Principal Investigator  
Ronald C. Arkin

3. Purpose of Research  
You are being asked to volunteer to complete a survey asking your opinions on the use of robots capable of lethal force in warfare. By analyzing these opinions, we hope to find out how acceptable such robots are to the public. This survey is sponsored by the Army Research Office.

4. Procedure  
You are asked to complete a survey asking your opinions on the use of robots capable of lethal force in warfare. This survey will be fully web-based, and no paper or direct interaction with others will be required. Your time commitment should not exceed 30 minutes.

5. Foreseeable risks or discomforts:  
This research involves minimal risk, similar to that involved in any everyday activity, for example, reading your e-mail. However, some people may experience slight discomfort discussing the issues of using lethal force.

6. Benefits  
Although there are no direct benefits to you, your opinions may possibly help shape both future robotics research and potential policy that will govern the use of lethal robots in the military.

7. Compensation/Costs  
Neither costs nor compensation are involved with this survey.

8. Confidentiality  
The following procedures will be followed to keep your personal information confidential in this study: The data that is collected about you will be kept private to the extent allowed by law. To protect your privacy, your records will be kept under a code number rather than by name, and stored securely under lock and key; only study staff will be allowed to look at them. Your name and any other fact that might point to you will not appear when results of this study are presented or published. You should be aware, however, that the survey is not being run from a "secure" https server of the kind typically used to handle credit card transactions, so there is a small possibility that responses could be viewed by unauthorized third parties (e.g., computer hackers). Also, in general the web page software will log the IP address of the machine you use to access this page (e.g., 102.403.506.807), but otherwise no other information will be stored unless you explicitly enter it.

To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB will review study records. The sponsor of this study, Army Research Office, has the right to review study records as well. Again, your privacy will be protected to the extent allowed by law.

9. Injury/Adverse Reactions  
Reports of injury or reaction should be made to Ronald C. Arkin at (404) 894-8209. Neither the Georgia Institute of Technology nor the principal investigator has made provision for payment of costs associated with any injury resulting from participation in this study.

10. Contact Person  
If you have questions about the research, call or write to the principal investigator at:

Ronald C. Arkin  
College of Computing  
Georgia Institute of Technology  
Atlanta, GA 30332-0280  
(404) 894-8209 (voice)  
(404) 385-5251 (fax)  
arkin@cc.gatech.edu

11. Voluntary Participation/Withdrawal  
You have rights as a research volunteer. Taking part in this study is completely voluntary. If you do not take part, there is no penalty. You may stop taking part in this study at any time with no penalty. If you have any questions about your rights as a research volunteer, call or write:


The Institutional Review Board,  
Office of Research Compliance  
505 Tenth Street, 3rd Floor  
Georgia Institute of Technology  
Atlanta, Georgia 30332-0420  
(404) 894-6942 (voice)  
(404) 894-2081 (fax)  
IRB@gatech.edu

Thank you for your participation.

**\* By selecting 'I agree', I certify that I am 18 years old or older, have read the information in this consent form, and agree to participate in this survey.**

I Agree  
 I Do Not Agree

Page 2 of 18

 Consent Form Approved by Georgia Tech IRB: February 20, 2007 - November 26, 2007

<< Prev Next >>

**Screenshot 2: Consent Form.**

Pages 3 and 4 form the first, introductory section of the survey, and contain questions 1-5.

**Page 3: Questions 1 and 2.** These questions assessed prior knowledge about robots in general and in the military.

**1. For each of the following, which would you consider to be a robot, by your own definition or experience?**

|  | Yes                   | No                    | Don't Know            |
|--|-----------------------|-----------------------|-----------------------|
| A human-like machine                                     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| An automated arm used in manufacturing                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| An unmanned vehicle, for example, a car without a driver | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| A radio-controlled vehicle, such as a battlebot          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 3: Page 3, Question 1.**

**2. Which of these characteristics do you think state-of-the-art military robots currently have?**

|  | Yes                   | No                    | Don't know            |
|--|-----------------------|-----------------------|-----------------------|
| Can make decisions about engaging an enemy by itself     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Can make ethical decisions and act upon them by itself   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Carries a weapon capable of lethal force                 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Can move around safely by itself                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Can recognize and target objects or people automatically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 4: Page 3, Question 2.**

**Page 4: Questions 3-5.** These questions assessed prior attitudes towards using human soldiers and robots during warfare in lethal capacity.

**3. In general, to what extent do you agree or disagree that it is acceptable for a soldier to take the life of a human combatant during warfare?**

Strongly Agree    Agree    Neither Agree nor Disagree    Disagree    Strongly Disagree    No Opinion/ Don't Know

**4. To what extent do you agree or disagree that it is acceptable for a military robot to take the life of a human combatant during warfare, if it first asks for direct confirmation from another human being?**

Strongly Agree    Agree    Neither Agree nor Disagree    Disagree    Strongly Disagree    No Opinion/ Don't Know

**5. To what extent do you agree or disagree that it is acceptable for a military robot to take the life of a human combatant during warfare, without asking for direct confirmation from another human being?**

Strongly Agree    Agree    Neither Agree nor Disagree    Disagree    Strongly Disagree    No Opinion/ Don't Know

**Screenshot 5: Page 4, Questions 3-5.**



Pages 6-11 constitute the main section of the survey.

**Page 6: Definitions and Questions 6-8 (Roles).** Definitions were first introduced on this page, at the beginning of the main section, and then were repeated on every page of the section. The questions on this page refer to possible roles that human soldiers and robots may take. The ordering of questions below is for version A, where the question regarding the human soldier is presented on the page first, followed by the one regarding the robot as extension of a human soldier, and then finally the one regarding the autonomous robot. In version B, the order of the questions including their numbers was reversed: question 6 was the one regarding the autonomous robot, and question 8 – regarding the human soldier; question 7, regarding the robot as extension, still occupied the intermediate position.

For the rest of the survey, we will be using some terms that should be defined the same for everyone. Please look through them and try to think of them whenever we use them in the questions. They will be repeated at the top of each page for your convenience. These terms are:

- **Robot:** as defined for this survey, an automated machine or vehicle, capable of independent perception, reasoning, and action
- **Robot acting as an extension of a human soldier:** a robot under the direct authority of a human, including authority over the use of lethal force
- **Autonomous robot:** a robot that does not require direct human involvement, except for high-level mission tasking; such a robot can make its own decisions consistent with its mission without requiring direct human authorization, including decisions regarding the use of lethal force

**Screenshot 6: Page 4, Definitions.**

**6. To what extent do you agree or disagree that it is acceptable for a human soldier to be employed in EACH of the following roles:**

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/ Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|------------------------|
| Crowd/mob control                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Day-night sentry / Perimeter surveillance | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Prison guard                              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Hostage rescue                            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Information gathering / Reconnaissance    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Direct combat - air, ground or sea        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |

**Screenshot 7: Page 5, Question 6.**

**7. To what extent do you agree or disagree that it is acceptable for a military robot acting as an extension of a human soldier to be employed in EACH of the following roles:**

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/ Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|------------------------|
| Crowd/mob control                       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Day-night sentry/Perimeter surveillance | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Prison guard                            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Hostage rescue                          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Information gathering / Reconnaissance  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |
| Direct combat - air, ground or sea      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  |

**Screenshot 8: Page 5, Question 7.**



8. To what extent do you agree or disagree that it is acceptable for an autonomous military robot, operating under the same rules of engagement as for a human soldier, to be employed in EACH of the following roles:

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Crowd/mob control                       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Day-night sentry/Perimeter surveillance | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Prison guard                            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Hostage rescue                          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Information gathering/ Reconnaissance   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Direct combat - air, ground or sea      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Screenshot 9: Page 5, Question 8.

**Page 6: Questions 9-11 (Situations).** These questions refer to possible situations for use of human soldiers and robots in warfare. Similarly to Page 5, the questions below are for version A, and the order of the questions in version B is reversed.

- **Robot:** as defined for this survey, an automated machine or vehicle, capable of independent perception, reasoning, and action
- **Robot acting as an extension of a human soldier:** a robot under the direct authority of a human, including authority over the use of lethal force
- **Autonomous robot:** a robot that does not require direct human involvement, except for high-level mission tasking; such a robot can make its own decisions consistent with its mission without requiring direct human authorization, including decisions regarding the use of lethal force

Screenshot 10: Page 6, Definitions repeated.

9. To what extent do you agree or disagree that it is acceptable for a human soldier to take human life, in a manner consistent with the existing laws of war, in EACH of the following situations:

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Open warfare, with the war on foreign territory | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Open warfare, with the war on home territory    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on foreign territory          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on home territory             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Screenshot 11: Page 6, Question 9.

10. To what extent do you agree or disagree that it is acceptable for a military robot acting as an extension of a human soldier to take human life, in a manner consistent with the existing laws of war, in EACH of the following situations:

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Open warfare, with the war on foreign territory | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Open warfare, with the war on home territory    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on foreign territory          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on home territory             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Screenshot 12: Page 6, Question 10.

11. To what extent do you agree or disagree that it is acceptable for an **autonomous military robot** to take human life, in a manner consistent with the existing laws of war, in EACH of the following situations:

|   | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|---|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Open warfare, with the war on foreign territory | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Open warfare, with the war on home territory    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on foreign territory          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Covert operations on home territory             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Screenshot 13: Page 6, Question 11.

Questions 12-15 on pages 7 and 8 elicit opinions on ethical considerations of using robots in warfare.

Page 7: Questions 12 and 13.

12. In your opinion, for a **human soldier** to act in an ethical manner during warfare means:

|   | Yes                   | No                    | Don't Know            |
|---|-----------------------|-----------------------|-----------------------|
| a) Following international protocols that specify the laws for ethical conduct of war, such as the Geneva Convention      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b) Following rules of engagement that specify rules which should guide actions during specific situations in the military | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c) Following a code of conduct which specifies how to behave in general in the military                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d) Following additional moral standards, above and beyond those specified in parts a-c                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Screenshot 14: Page 7, Question 12.

13. In your opinion, for an **autonomous military robot** to act in an ethical manner during warfare means:

|   | Yes                   | No                    | Don't Know            |
|---|-----------------------|-----------------------|-----------------------|
| a) Following international protocols that specify the laws for ethical conduct of war, such as the Geneva Convention      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b) Following rules of engagement that specify rules which should guide actions during specific situations in the military | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c) Following a code of conduct which specifies how to behave in general in the military                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d) Following additional moral standards, above and beyond those specified in parts a-c                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Screenshot 15: Page 7, Question 13.

Page 8: Questions 14 and 15.

14. If robots could act ethically in warfare, to what ethical standards should they be held to? Please pick one:

- Higher ethical standards than a human soldier
- Lower ethical standards than a human soldier
- The same ethical standards as a human soldier

15. To what extent do you agree or disagree that an **autonomous military robot** should be able to refuse an order from a human commander it interprets to be unethical?

- Strongly Agree
- Agree
- Neither Agree nor Disagree
- Disagree
- Strongly Disagree
- No Opinion/Don't Know

Screenshot 16: Page 8, Questions 14 and 15.

**Page 9: Questions 16 - 18.** These questions determine the perceived responsibility for any lethal errors made by human and robot soldiers. They also were counterbalanced for order, and the screenshots below are from version A (the order is reversed in version B).

**16. In general, if a human soldier takes a human life in error, to what extent could EACH of the following parties be responsible?**

|                                   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|-----------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Human soldier                     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Higher-level military authorities | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Politicians                       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 16: Page 9, Question 16.**

**17. In general, if a military robot as an extension of a human soldier takes a human life in error, to what extent could EACH of the following parties be responsible?**

|                                       | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|---------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Robot itself                          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Human soldier in control of the robot | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Robot designer                        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Higher-level military authorities     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Politicians                           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 17: Page 9, Question 17.**

**18. In general, if an autonomous military robot takes a human life in error, to what extent could EACH of the following parties be responsible?**

|                                   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|-----------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Robot itself                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Robot designer                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Higher-level military authorities | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Politicians                       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 18: Page 9, Question 18.**



**Page 10: Questions 19 and 20.** These questions were designed to compare benefits of and concerns for using robots in warfare.

**19. To what extent do you think EACH of the following is a potential BENEFIT of using military robots capable of taking human life in warfare?**

|   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Saving lives of soldiers                                | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Saving civilian lives                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Reducing long-term psychological trauma to soldiers     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Reducing the financial cost of using soldiers in combat | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Producing better battlefield outcomes                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decreasing friendly fire incidents                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 19: Page 10, Question 19.**

**19. To what extent do you think EACH of the following is a potential BENEFIT of using military robots capable of taking human life in warfare?**

|   | Very Significantly    | Significantly         | Somewhat              | A Little              | Not at All            | No Opinion/Don't Know |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Saving lives of soldiers                                | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Saving civilian lives                                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Reducing long-term psychological trauma to soldiers     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Reducing the financial cost of using soldiers in combat | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Producing better battlefield outcomes                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Decreasing friendly fire incidents                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 20: Page 10, Question 20.**

**Page 11: Questions 21 and 22.**

**21. To what extent do you think bringing military robots onto the battlefield would make it harder or easier for humans to start wars?**

Much Harder   
  Harder   
  Neither Harder nor Easier   
  Easier   
  Much Easier   
  No Opinion/Don't Know

**22. If it were possible for a military robot to have emotions, to what extent do you agree or disagree that EACH of the following emotions could be beneficial for it to have:**

|           | Strongly Agree        | Agree                 | Neither Agree nor Disagree | Disagree              | Strongly Disagree     | No Opinion/Don't Know |
|-----------|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|-----------------------|
| Anger     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Guilt     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Happiness | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Sympathy  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Fear      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Screenshot 21: Page 11, Questions 21 and 22.**

Questions 23-44 on pages 12-17 constitute the demographics section of the survey.

**Page 12: Questions 23-25.**

Please answer the following questions about yourself:

**23. What is your gender?**

- Female
- Male

**24. What is your age?**

**25. Were you raised in the US?**

- Yes
- No

Screenshot 22: Page 12, Questions 23-25.

**Page 23: Questions 26 and 27.** Only those who answered affirmatively to question 25 were directed to this page.

**26. What region of the world were you raised in as a child?**

- North America, excluding US
- Central or South America
- Asia
- Western Europe
- Eastern Europe
- Middle East
- Africa
- Australasia, including Australia, New Zealand and surrounding islands
- Other (please specify)

**27. How long have you lived in the US?**

# of years:

Screenshot 23: Page 13, Questions 26 and 27.

**Page 14: Questions 28-33 (Educational and professional background).**

**28. What is the highest level of education you have achieved?**

|                     | Completed             | Working/Worked Towards |
|---------------------|-----------------------|------------------------|
| Elementary school   | <input type="radio"/> | <input type="radio"/>  |
| High school         | <input type="radio"/> | <input type="radio"/>  |
| Bachelor's Degree   | <input type="radio"/> | <input type="radio"/>  |
| Postgraduate Degree | <input type="radio"/> | <input type="radio"/>  |

**29. If you have completed your Bachelor's or postgraduate degree, what was your major?**

Bachelor's Degree

Postgraduate Degree

**30. What is your current occupation?**

**Screenshot 24: Page 14, Questions 28-30.**

**31. Are you involved or have been involved with policymaking for the local, state or federal government, or the military in any way?**

Yes  
 No  
 Not Sure

**32. Have you had any robotics research experience?**

Yes  
 No  
 Not Sure

**33. Have you had any military experience?**

Yes  
 No

**Screenshot 25: Page 14, Questions 31-33.**

**Page 15: Questions 34-37 (Military Background).** Only those who answered affirmatively to question 33 were directed to this page.

**34. How long have you served in the military, including reserves and active duty? For example, 2 years and 5 months.**

# of years

and months

**35. What is your highest achieved military rank?**

**36. What branch of the military are/were you associated with? Please choose one.**

Army

Air Force

Navy

Marine Corps

Coast Guard

Other (please specify)

**37. How much combat experience have you had, if any, using or directly observing the use of lethal force?**

Very Significant     Significant     Some     A Little     None

**Screenshot 26: Page 15, Questions 34-37.**

**Page 16, Questions 38-42 (Attitude towards technology and robots).**

**38. How much practical experience have you had, if any, with EACH of the following technologies?**

|                    | Very Significant      | Significant           | Some                  | A Little              | None                  |
|--------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Personal Computers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Internet           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Video Games        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Robots             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Firearms           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**39. How would you describe your attitude towards technology in general?**

Very Positive     Positive     Neutral     Negative     Very Negative     No Opinion

**Screenshot 27: Page 16, Questions 38-39.**

**40. If you had significant previous personal, work, or education-related experience with robots, what types of robots were they?**

|                                   | Yes                   | No                    |
|-----------------------------------|-----------------------|-----------------------|
| Industrial robots                 | <input type="radio"/> | <input type="radio"/> |
| Research robots                   | <input type="radio"/> | <input type="radio"/> |
| Military Robots/Unmanned Vehicles | <input type="radio"/> | <input type="radio"/> |
| Entertainment robots              | <input type="radio"/> | <input type="radio"/> |
| Service robots                    | <input type="radio"/> | <input type="radio"/> |
| Humanoid robots                   | <input type="radio"/> | <input type="radio"/> |
| Hobby robots                      | <input type="radio"/> | <input type="radio"/> |
| Other                             | <input type="radio"/> | <input type="radio"/> |

**41. How would you describe your attitude towards robots in general?**

Very Positive  
  Positive  
  Neutral  
  Negative  
  Very Negative  
  No Opinion

**42. How do you believe mass media (books, movies, TV, video games, etc.) has influenced your current attitude towards robots?**

Very Strongly  
  Strongly  
  Somewhat  
  A Little  
  Not at All  
  No Opinion

**Screenshot 28: Page 16, Questions 40-42.**

**Page 17, Questions 43 and 44.**

**43. In your opinion, how avoidable or inevitable are wars?**

Always Avoidable  
  Mostly Avoidable  
  Sometimes Avoidable and Sometimes Inevitable  
  Mostly Inevitable  
  Always Inevitable  
  No Opinion

**44. To what extent do you consider yourself a religious or spiritual person?**

Very Significantly  
  Significantly  
  Somewhat  
  A Little  
  Not at All  
  No Opinion

**Screenshot 29: Page 17, Questions 43-44.**

**Page 18: Question 45.** An open-ended question to elicit opinions and concerns not expressed otherwise.

45. Please list any specific issues or concerns that were not addressed in this survey that you may have with the potential military use of robots capable of taking human life. Be as specific as possible.

**Screenshot 30: Page 18, Question 45.**



## Page 19: The Last (Concluding) Page of the Survey.

This concludes the survey - thank you very much for your participation. Your comments are valuable to us, and will provide us with insights for further research.

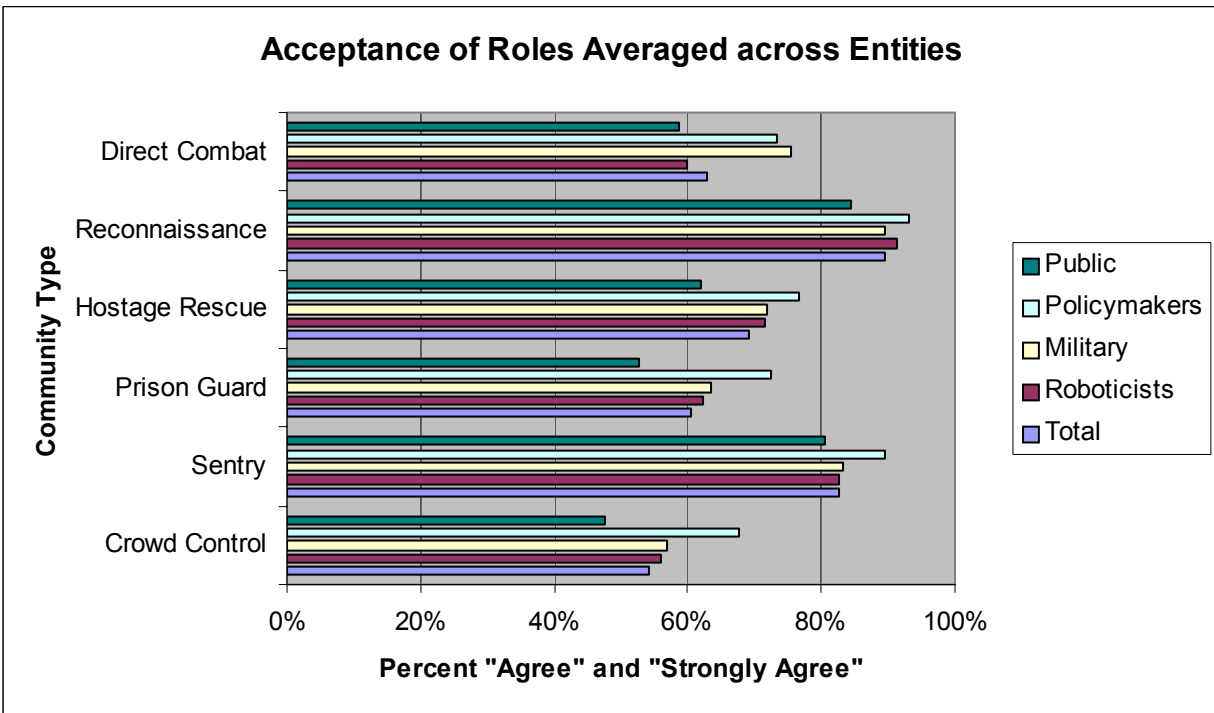
If you would like to have access to the results of the survey when they become available, please enter your e-mail below:

<< Prev Done >>

**Screenshot 31: Page 19, Concluding Page.**

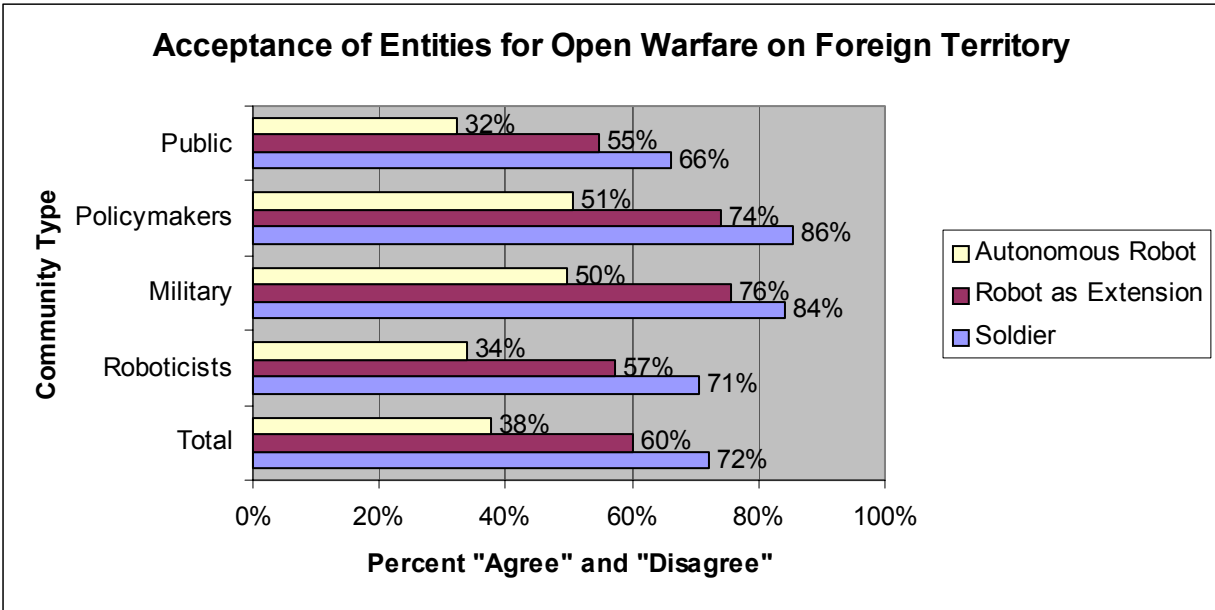
APPENDIX B: ADDITIONAL ANALYSIS FOR SECTION 3.1

Appendix B.1: Roles

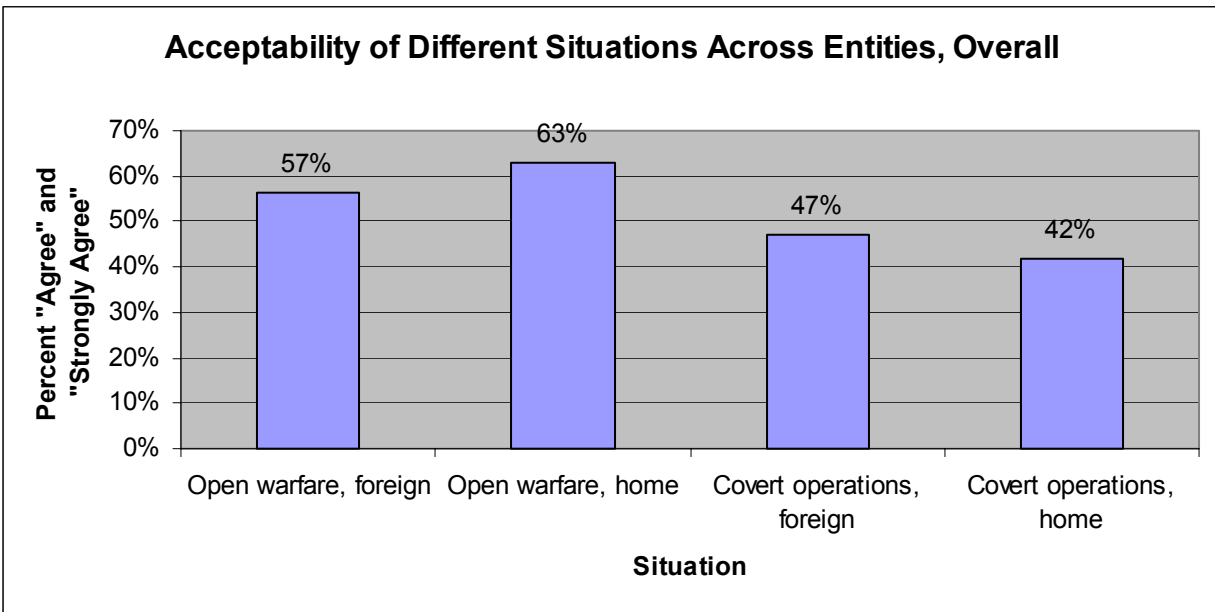


**Figure 42: Acceptance of roles averaged across entities for each community type. In most cases, the general public is the least accepting of the use of soldiers and robots in these roles, and the policymakers are the most accepting.**

## Appendix B.2: Situations

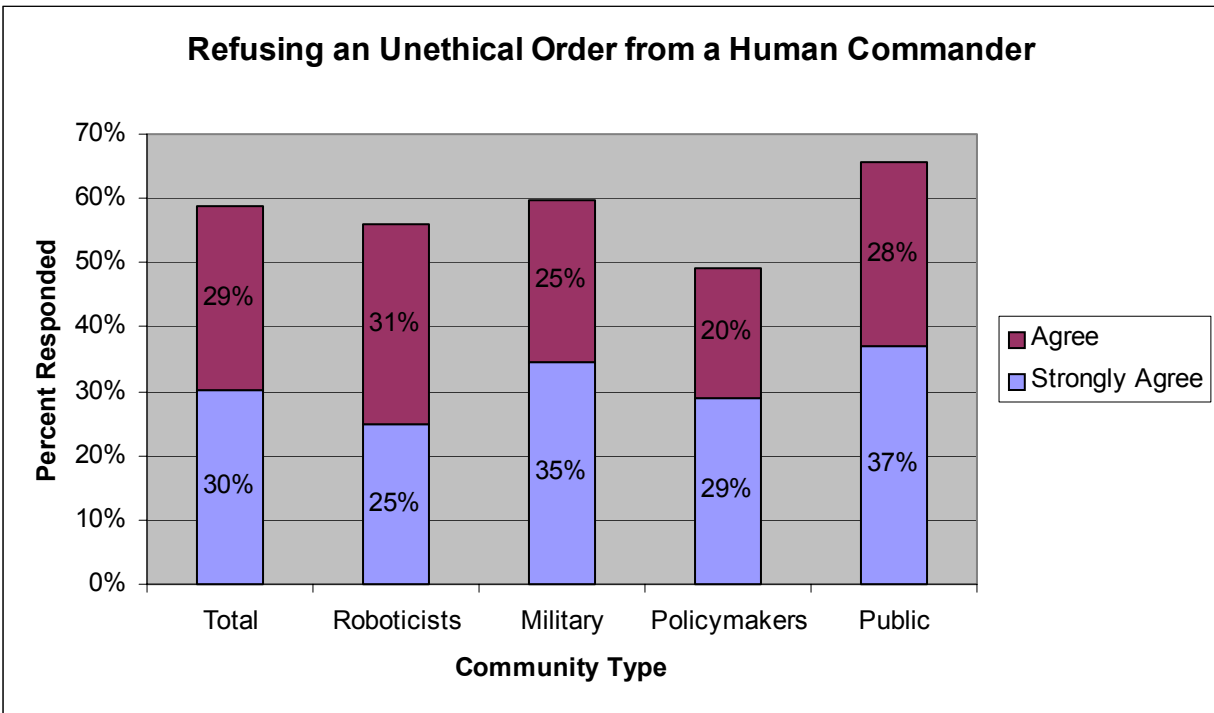


**Figure 43: Acceptance of Entities for Open Warfare on Foreign Territory. General public is the least accepting, and policymakers and higher-level military are the most.**



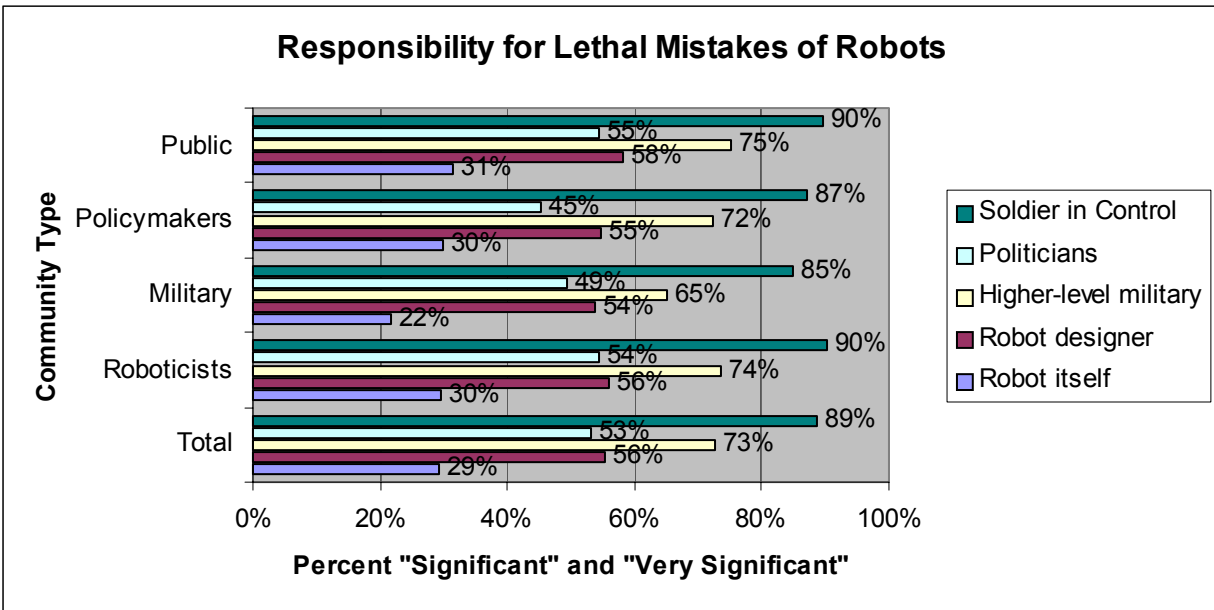
**Figure 44: Acceptability of Different Situations across Entities (All the participants). Note that Covert Operations were favored less.**

### Appendix B.3: Ethical Considerations



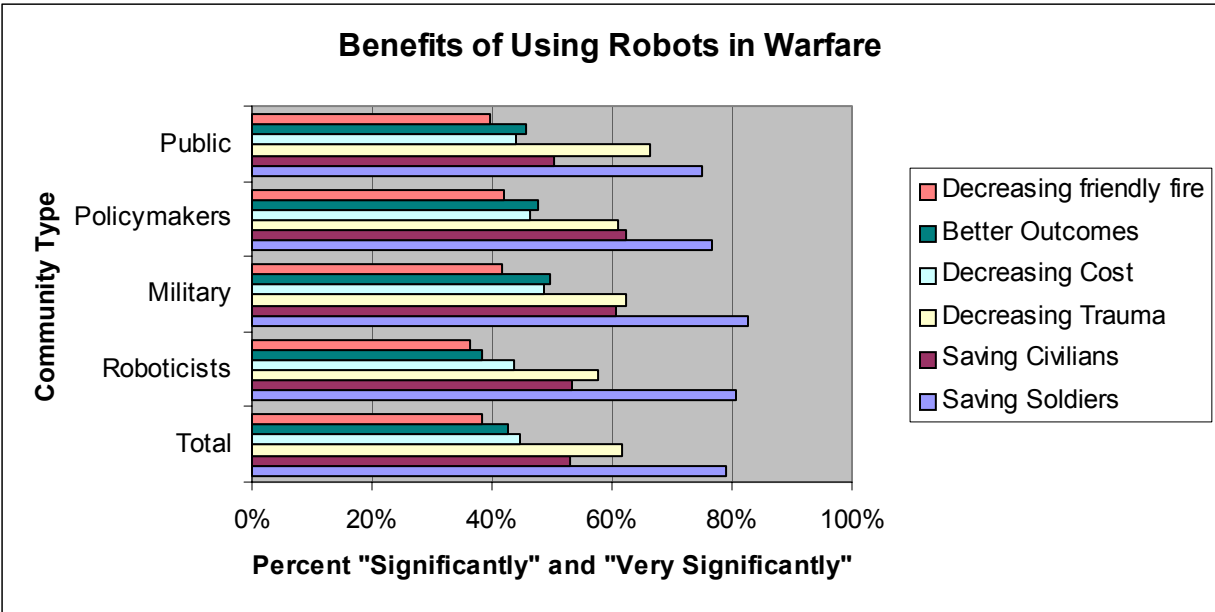
**Figure 45: Refusing an Unethical Order from a Human Commander. Majority of the participants believed that a robot should have a right to refuse an unethical order. Military were the least likely to allow a robot this right.**

## Appendix B.4: Responsibility

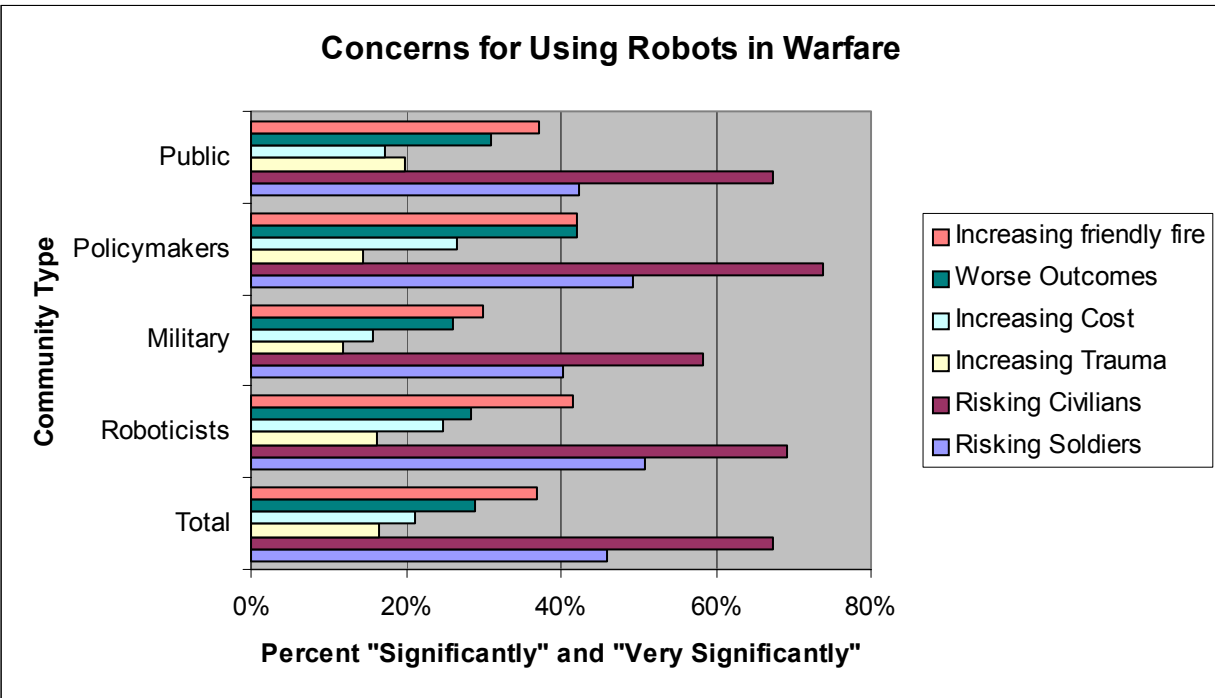


**Figure 46: Responsibility for Lethal Mistakes of Robots, Averaged between Robot as an Extension and Autonomous Robot. Policymakers were the least likely community type to blame politicians for robot errors, and military least likely to blame higher-level military authorities.**

## Appendix B.5: Benefits and Concerns

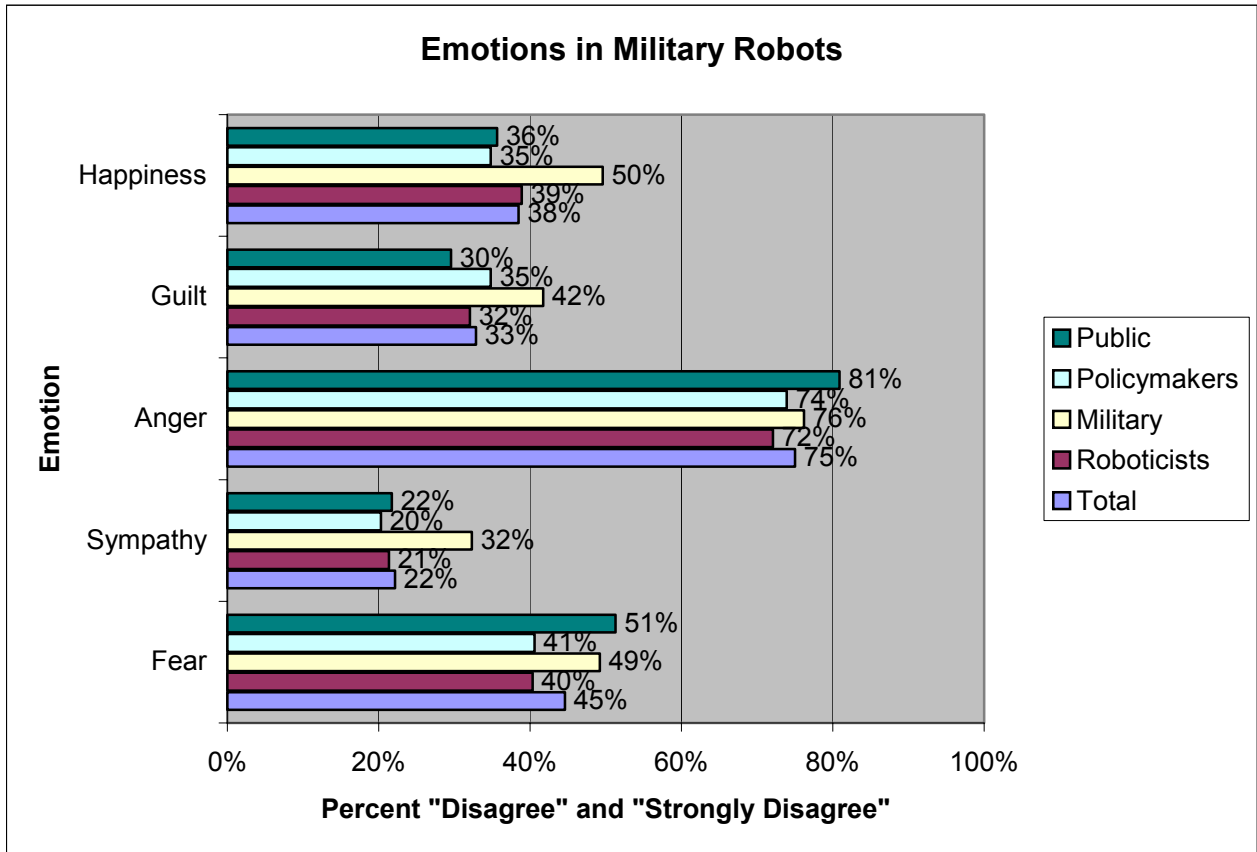


**Figure 47: Benefits of Using Robots in Warfare, Arranged by Community Type. Roboticists were not likely to consider “Decreasing Friendly Fire” a benefit, and general public considered “Decreasing Trauma to Soldiers” more of a benefit than any other community type.**



**Figure 48: Concerns for Using Robots in Warfare, Arranged by Community Type. Military saw “Risking Civilian Lives” less of a concern than any other type. No other category was considered a concern by more than half of the participants.**

## Appendix B.6: Wars and Emotions



**Figure 49: Emotions in Military Robots: Percent Disagree and Strongly Disagree. Anger was considered by far the most undesirable emotion in a military robot. Those with military experience were the least likely to consider emotions than any other community type.**

APPENDIX C: ADDITIONAL ANALYSIS FOR SECTION 3.2

Appendix C.1: Roles

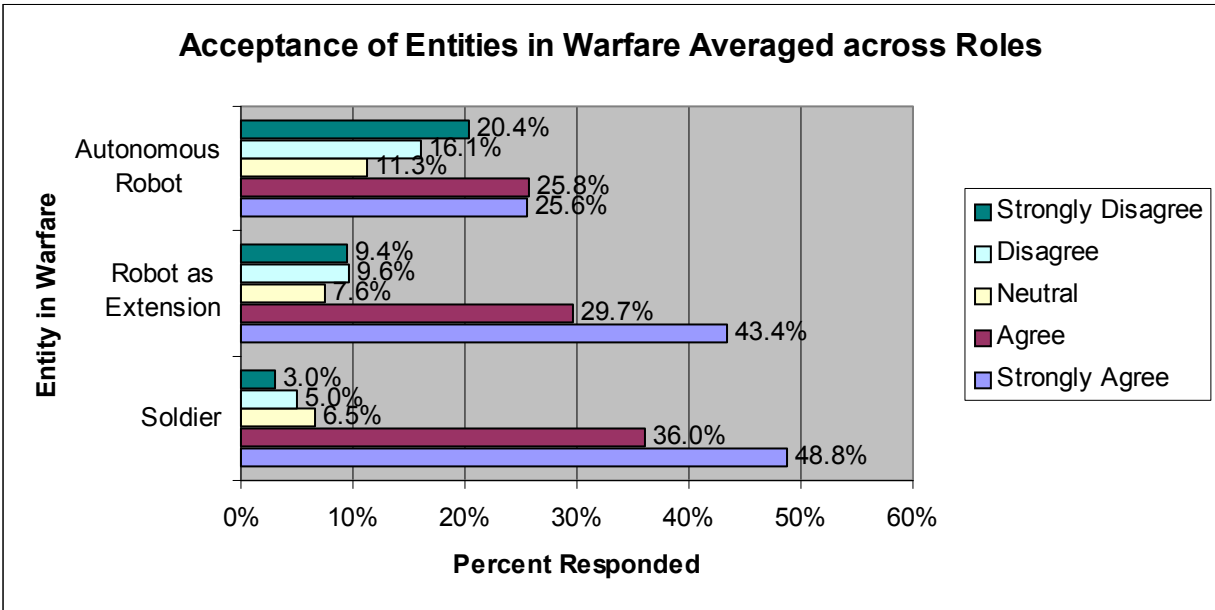


Figure 50: Acceptance of Entities in Warfare Averaged across Roles. Soldier was the entity accepted the most uniformly, and autonomous robot caused the most disagreement regarding its use in warfare.

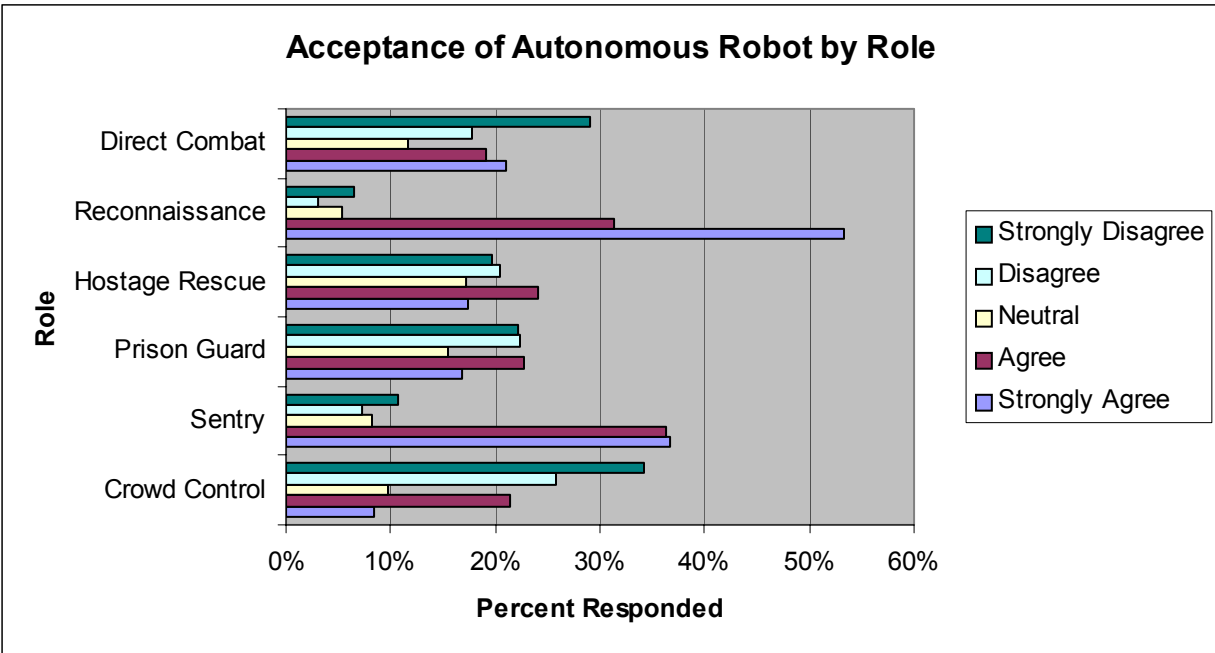
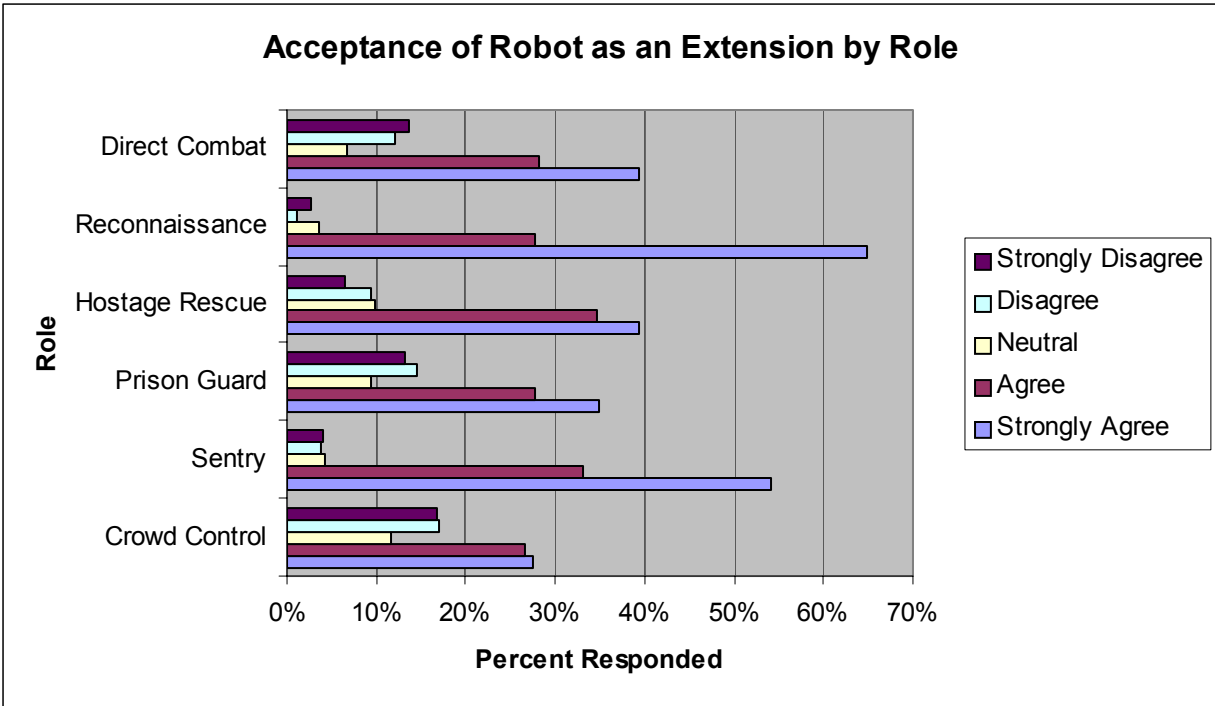
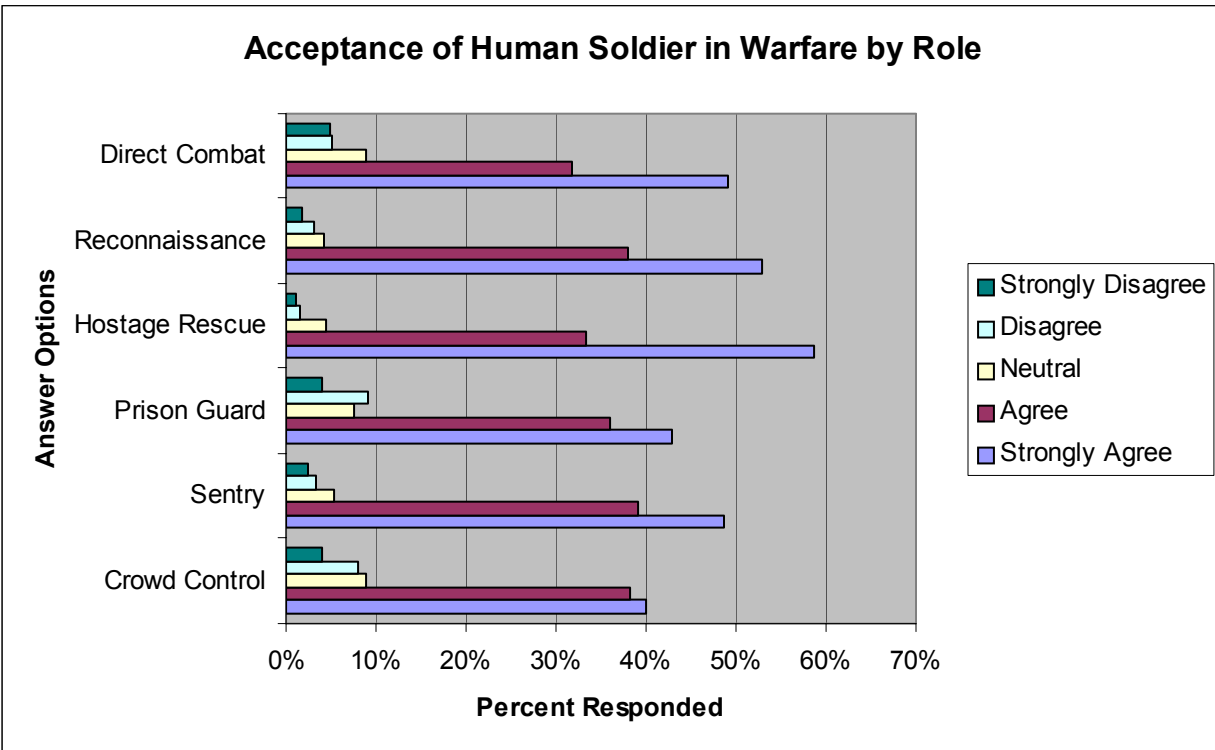


Figure 51: Acceptance of Autonomous Robot by Role. Crowd Control and Direct Combat were the roles for which participants disagreed the most with the use of autonomous robot.



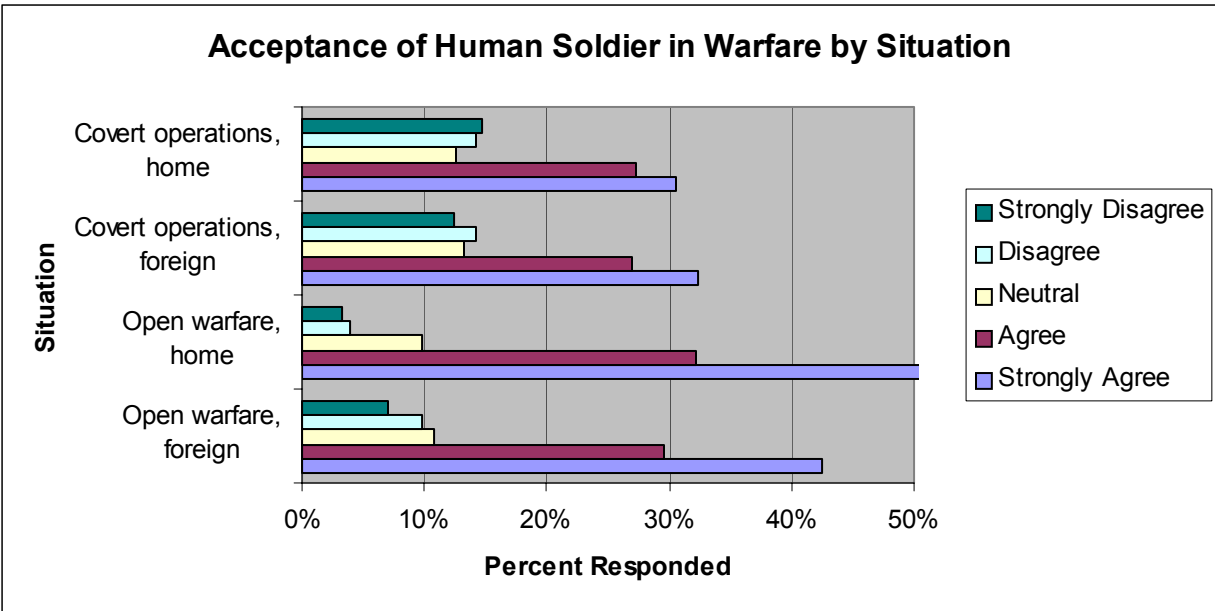


**Figure 52: Acceptance of Robot as an Extension by Role. Reconnaissance and Sentry were the most acceptable roles for robot as an extension.**

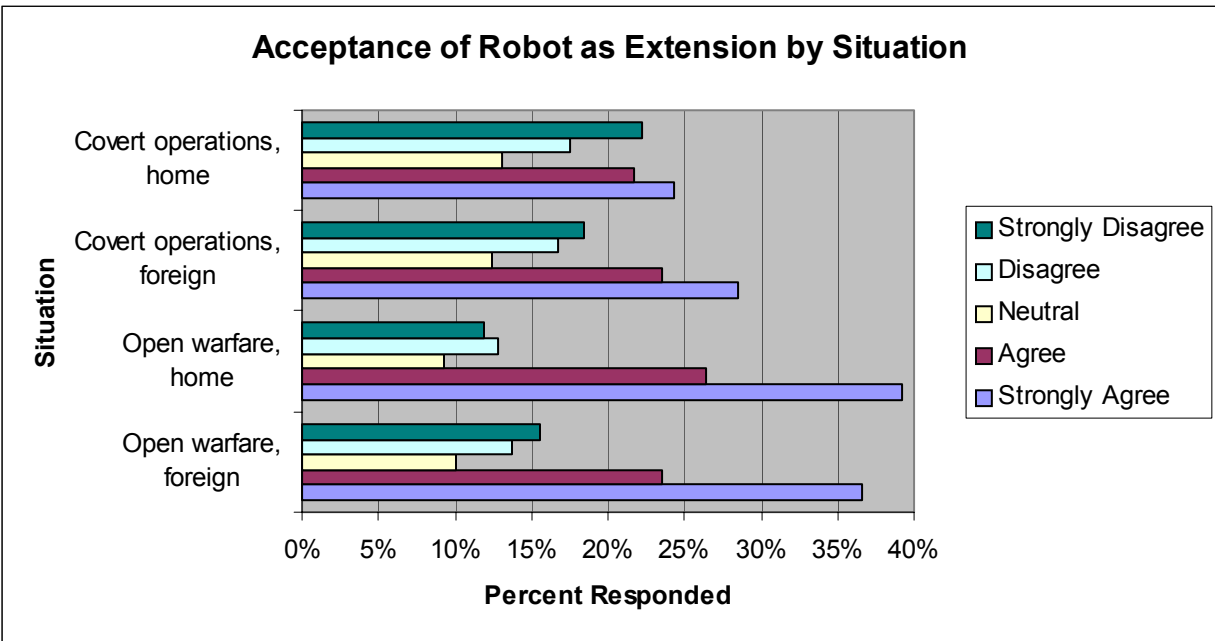


**Figure 53: Acceptance of Human Soldier in Warfare by Role. There was less difference between roles in the case of a soldier than in the cases of either a robot as an extension or an autonomous robot.**

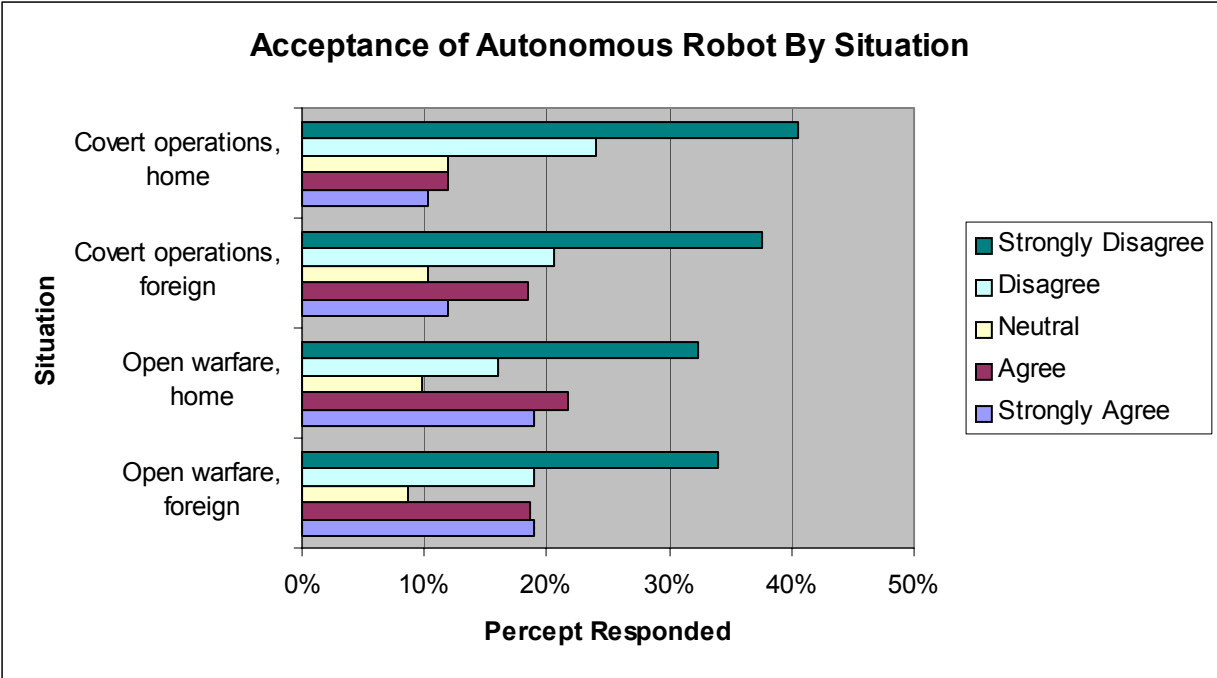
## Appendix C.2: Situations



**Figure 54: Acceptance of Human Soldier in Warfare by Situation. Open Warfare on Home Territory was the least acceptable situation for a soldier to be involved in.**

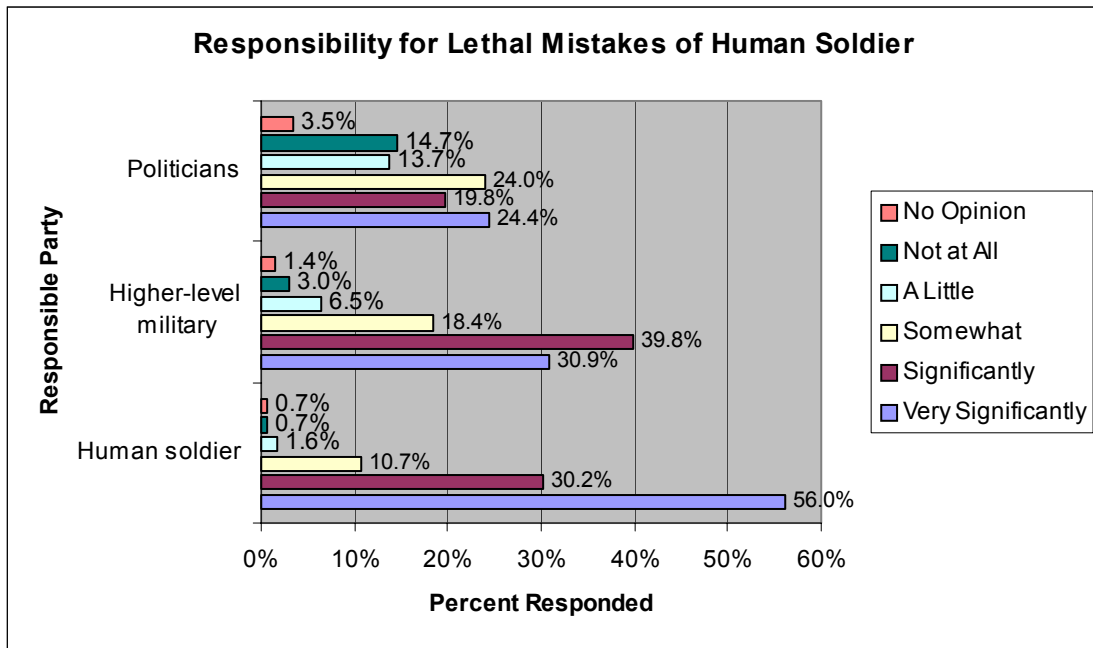


**Figure 55: Acceptance of Robot as Extension by Situation. There was considerable disagreement over the use of a robot as an extension for covert operations.**

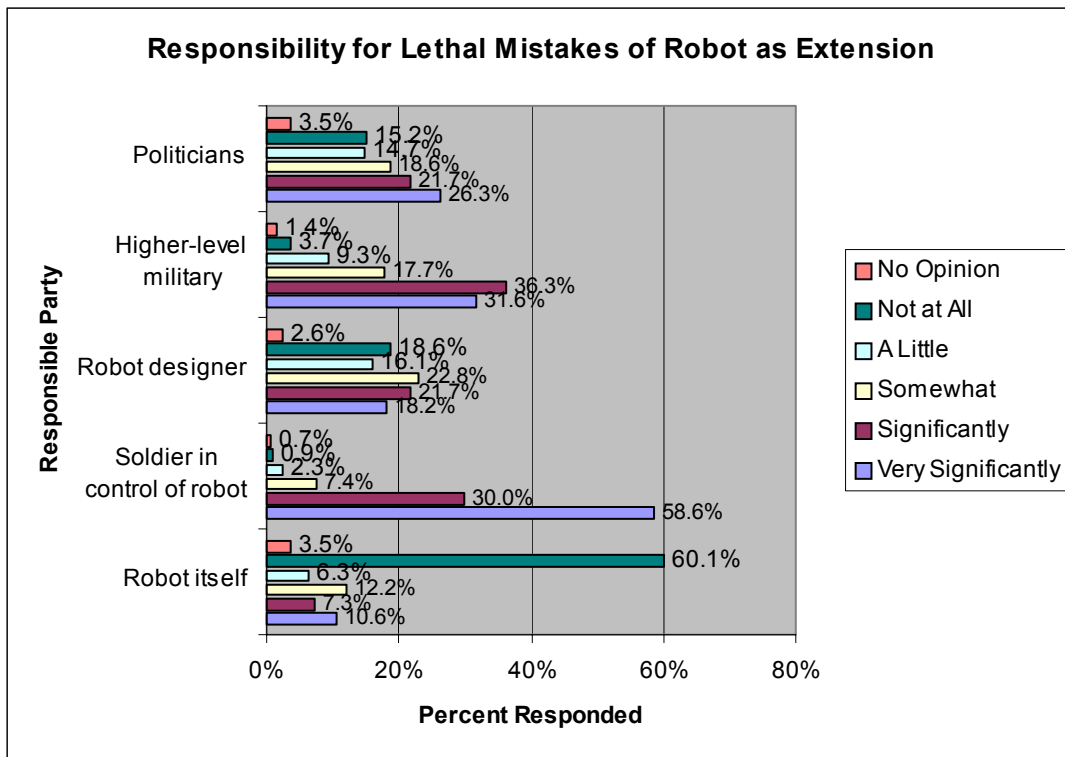


**Figure 56: Acceptance of Autonomous Robot by Situation. More participants disagreed with the use of an autonomous robot in any of the situations than they agreed with, especially for Covert Operations on Home Territory**

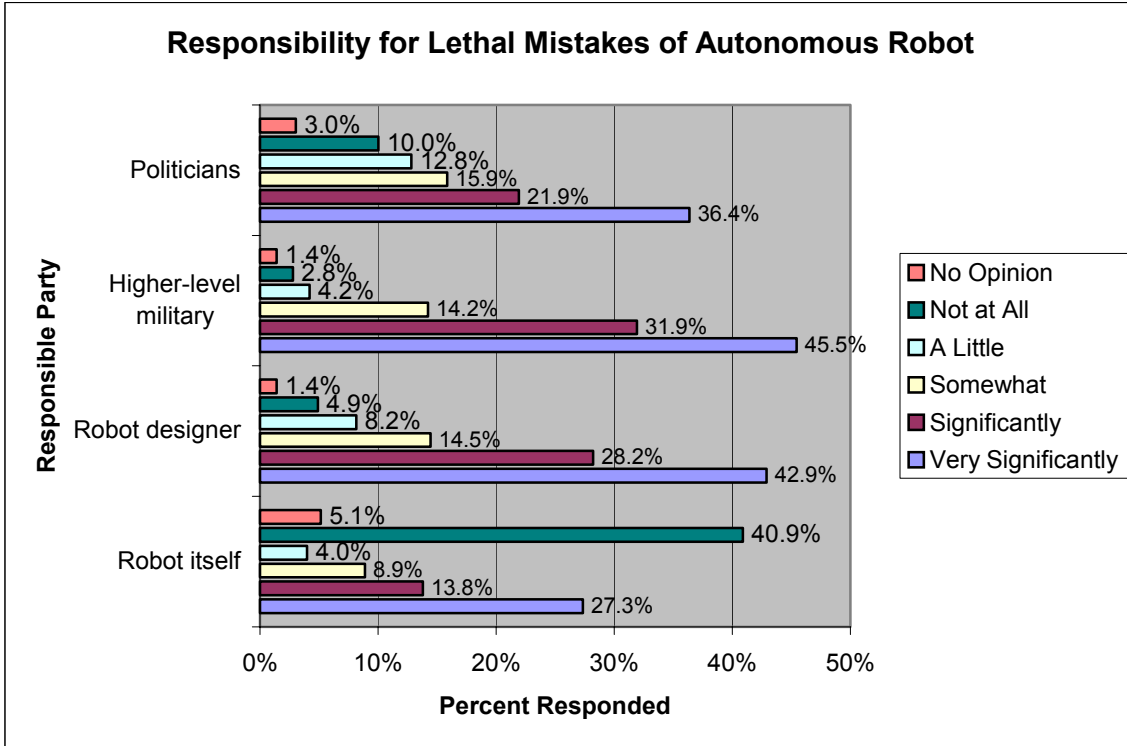
### Appendix C.3: Responsibility



**Figure 57: Responsibility for Lethal Mistakes of Human Soldier. Hardly anyone thought that a soldier was not responsible for his/her own mistakes, whereas the opinions on politicians’ responsibility were divided.**



**Figure 58: Responsibility for Lethal Mistakes of Robot as Extension. Most participants were in agreement that a robot as an extension of a human soldier was not to blame for its mistakes; rather, the soldier in control was considered to blame the most.**



**Figure 59: Responsibility for Lethal Mistakes of an Autonomous Robot. Higher-level military authorities and the robot designer were considered almost equally responsible for an autonomous robot’s fatal errors. The opinions on the robot’s responsibility were widely divided.**