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Survey-Based Discussions on Morally Contentious Applications of Interactive Robotics

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Abstract *Introduction*: As applications of robotics extend to areas that directly impact human life, such as the military and eldercare, the deployment of autonomous and semi-autonomous robots increasingly requires the input of stakeholder opinions. Up to now, technological deployment has been relying on the guidance of government/military policy and the healthcare system without specific incorporation of professional and lay opinion. *Methods*: This paper presents results from a roboethics study that uses the unique N-Reasons scenario-based survey instrument. The instrument collected Yes, No, Neutral responses from more than 250 expert and lay responders via the Internet along with their ethics-content reasons for the answers, allowing the respondents to agree to previously-provided reasons or to write their own. Data from three questions relating to military and eldercare robots are analyzed qualitatively and quantitatively. *Results*: The survey reveals that respondents weigh the appropriateness of robotics technology deployment in concert with the level of autonomy conferred upon it. The accepted level of robot autonomy does not appear to be solely dependent on the perceived efficiency and effectiveness of the technology, but is subject to the robot's relationship with the public's principle-based reasons and the application field in focus. *Conclusion*: The N-Reasons instrument was effective in eliciting ethical commentary in a simple, on-line survey format and provides insights into the interactions between the issues that respondents consider across application and technology boundaries.

Keywords Roboethics · Survey · Military robots · Eldercare robots · Social robotics

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1 Introduction

The young field of Roboethics [24] grapples with the ethical use of robots in society as well as the challenge of endowing the behavior of interactive robots with ethical values [3]. The deployment of robotics in service applications is growing, and its penetration in some areas is established, such as cleaning, sentry and grass mowing. As other, more conflicted, applications grow, such as care for older persons and weapons deployment for the military, the public at large is clearly impacted at multiple levels—personally, as a member of a user community, and societally. The qualitative research study presented in this paper seeks to reveal stakeholder perceptions of what constitute socially appropriate robot behaviors using contemporary and near-future social robotics examples. Stakeholders in ethical robot design range from society at large (military robotics) to ambient technology users (autonomous transportation) to persons seeking more functional independence (assistive robotics).

It is considered best practice in the research and development of sensitive medical and technological advances to consider ethics up front and in-step with the advances themselves, not as an afterthought, to maximize the effective-

ness and appropriateness of scientific progress. Using scientific knowledge for peace and well-being is aligned with the philosophy of the United Nations Educations, Scientific and Cultural Organization (UNESCO) that peace must be founded upon the intellectual and moral solidarity of humankind. Julian Huxley, the first Director-General of UNESCO, has pointed out that *"in order to make science contribute to peace, security and human welfare, it would be necessary to relate the applications of science to a general scale of values"* [12]. In the face of the development of automation technology that can, depending on its design, be equally efficient in either killing or saving humans, how can human values be determined in context and then applied to our society's deployment of such capabilities? This roboethics question is addressed in the present study by the application of a rich survey instrument, N-Reasons.

In the present study, our focus is in two application fields of service robots: military weaponry and care for older persons. These were chosen as being representative of two different levels of technology involvement by the individual stakeholder: societal and personal. Our study builds on standard surveys to understand the public's opinion on robotics technology in general [22], as well as the specific application of the technology for military missions [14]. The novel N-Reasons scenario-based survey instrument, unlike traditional survey platforms, allows respondents to choose a reason given by previous respondents or to enter a new reason for voting Yes, No, or Neutral to each question posed. This approach quickly reduces the reason space to broad convergent categories while encouraging iterative re-wordings for clarity.

In the following sections, we present the relevant background of ethics, robotics and qualitative research methods, our methodology in setting up the survey, our results related to three key survey questions, and an extensive discussion on the implications of the insights developed by the more than 250 persons who contributed their opinions to this on-line survey.

2 Background

Until the mid-nineteenth century, technology was considered a simple application of science and remained as an uninteresting topic for discussion by philosophers [15]. Starting in the twentieth century, philosophers gradually began to focus specifically on the nature of technology and its implications for society [15]. Today, the recent advancement and deployment of robots in military and service fields in the past decades are bringing a rapid increase in the discussion of automation and technology by not only philosophers (e.g., Nagenborg, Sullins) but also roboticists (e.g., Arkin).

By the year 2008, the United States had an inventory of over 6000 military unmanned systems (robots) as compared to their inventory of 167 in 2002 [21], many deployed in the Iraq and Afghanistan wars; South Korea has already introduced sentry robots to guard the demilitarized zone on its northern border. In parallel with this trend, the debate concerning military robots has been escalating among philosophers, roboticists, ethicists as well as the lay public [13, 18, 19].

The eldercare robot sector has also been undergoing rapid deployment in recent years as many developed countries—most noticeably, Japan—have been planning to counterbalance their increased labor shortage with robots and automation. In fact, thousands of robots are already being used as certified medical devices in countries such as the United States and Denmark [23]. Guidelines for implementation of eldercare robots have been suggested along with expressions of caution [10, 17, 20].

Of these studies, only a few investigated the public's perception of roboethics issues. Using conventional online survey techniques, Moshikin and Arkin conducted an extensive investigation of stakeholder perspectives on military robots [14]. The results of this survey involving policy makers, the public, military personnel, and roboticists suggest that robots with increased autonomy are less likely to be accepted by the stakeholders, and that more than half of the participants believed that the taking of a human life by an autonomous robot is unacceptable.

A more general survey was conducted by Takayama et al., outside of the military application domain [22]. Her study focused on public perceptions of the acceptability of occupations for robots and humans. The results suggest that the characteristics of occupations are significant predictors of public attitudes toward robots.

The two abovementioned studies provide valuable insight into the public's perception of robot use in and for society. However, due to the nature of conventional survey platforms, the results of the studies do not offer insights into people's rationale and the priority in their moral reasoning pertaining to the issues of roboethics.

Along with some of the researchers before us [16, 20, 25], we advocate that assessing technologies imposing potential risks on communities ought to involve the opinions of user communities. Obviously, the public can be engaged in various ways and at different levels of abstraction—from taking into consideration their rights and interests at one extreme to face-to-face deliberative engagement at the other [8, 9].

In the study presented here, we employed a novel online survey platform, N-Reasons, that allows rapid and inexpensive polling of large groups yet provides reliable ethical reasoning user opinion data. Developed at the Centre for Applied Ethics at the University of British Columbia [6], the platform exploited an opportunity we uncovered to address a core problem with survey methods in ethics: the

framing effect of providing our chosen experts to flesh out scenarios [11]. The opportunity arose when we experimentally discovered that forcing participants to contribute reasons supporting their choices did not, as anticipated, decrease participation [4]. The N-Reasons platform makes participant-generated reasons central, and was used in conjunction with well-known recruitment methods—using randomly split populations to obtain experimental validity even with self-selected web-based respondent populations [1, 2, 6]. Based on this rationale, we developed an N-Reasons survey on roboethics, which is presented in the following sections.

3 Methods

The N-Reasons survey platform employed in this study captured both quantitative and qualitative responses to nine roboethics related questions. The focus of the questions ranged from issues of using robots for military weaponry, eldercare, therapy of children and seniors, and surveillance for the old, to issues of constructing robots that mimic human form, replacing hardware robots with remote controlled animals, and using robots that self mutilate for mine clearing purposes. A summary of the questions' quantitative analyses are provided in more detail in our previous work [6].

To outline the rich landscape of qualitative opinions surrounding the issues of robots in military weaponry and physical care of older persons in particular, we present the three questions specifically focused on the uses of robots in these two fields. Screenshots of the remaining six questions are presented in the Appendix (see Figs. 10 to 15). Section 3.1 describes the survey platform in greater detail.

The quantitative data collected from the survey are the vote counts for Yes, No, and Neutral answers to a given question. Each vote for one of the three answers is associated with the participant's reasons for choosing the answer. These reasons were entered as open texts or as votes to pre-existing reason(s) authored by another participant. We implemented the principles of grounded theory to process the qualitative data of reasons. We describe the details of the data collection and processing in Sect. 3.2.

3.1 N-Reasons Survey Platform

In our roboethics survey, a short description of a robot was provided before each survey question and established common background information on the topic for all participants. Of the nine questions presented in the survey in a fixed order, results presented here focus on the first three questions. These questions pertain to the military and eldercare robotics application fields.

Not all participants contributed to all of the questions. However, with a bare question pertaining to the described robot, the topic grew into a fuller scenario as participants added reasons for, neutral to, or against the question, or voted for existing reasons.

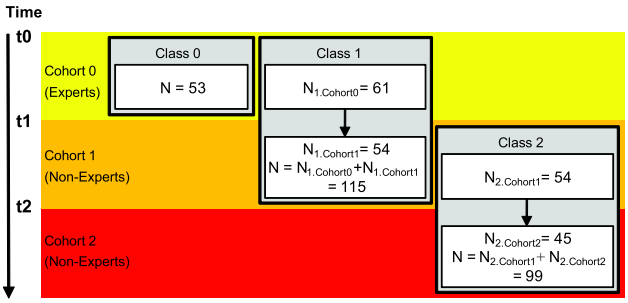

Fig. 1 Breakdown of cohorts and classes. The three cohorts in the survey participant recruitment periods resulted in the collection of data from three different classes of surveys. Class 0 contains only expert respondents, Class 1 a mix of expert and lay respondents, and Class 2 only lay respondents. The numbers of respondents presented here are based on those who completed all nine questions of our survey

The data reported here are from the first two runs of the survey. The survey respondents were recruited from blogs, Facebook groups, and mailing lists on robotics, as well as from broader populations attracted to other surveys on our site [5]. Further methodological details of the survey and the platform are provided in our related publications [4, 6, 7].

3.2 Data Collection and Coding Process

To shed light onto whether experts have different viewpoints than that of the lay public, a total of 300 participants were divided into three cohorts (0, 1, 2) and three classes (0-expert only, 1-expert and lay, 2-lay only). The breakdown of cohorts and classes is shown in Fig. 1.

In Cohort 0, two classes (Class 0 and 1) of surveys were open to the expert population. A call for participants was sent to targeted academics in the field of Roboethics, Philosophy, and Robotics via field-specific email lists. Participants from this cohort were randomly directed to either of the two classes.

In Cohort 1, non-experts were invited to participate in the survey via general mailing lists and other recruitment methods described in Sect. 3.1. Only Class 1 remained open such that it contains responses from experts followed by lay participants, whereas Class 0 contains responses from experts only. With the assumption that most expert participants had joined Cohort 0, a new class of survey (Class 2) was launched to collect responses from lay participants mostly. Lay participants in Cohort 1 were randomly directed to one of the two open classes—Class 1 or Class 2. In Cohort 2, only Class 2 remained open until approximately the same number of respondents had participated in Class 2 as in Class 1.

Our previous investigation into the dynamics of responses in the N-Reasons platform shows that as the number

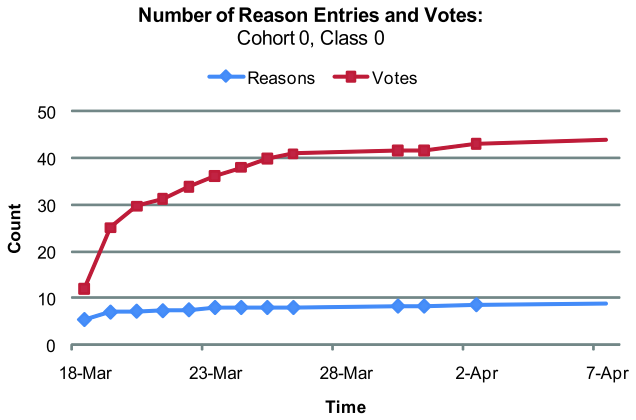

Fig. 2 The saturation characteristics of data collected by the N-Reasons survey platform demonstrated by data from Cohort 0, Class 0. As the number of votes increases over time, the number of new reason entries contributed to the survey declines and reaches stability. Respondents participating in the survey after the survey has reached the point of stability are most likely to vote for existing reasons rather than author new reason entries. This saturation characteristic holds true for all classes of surveys presented here

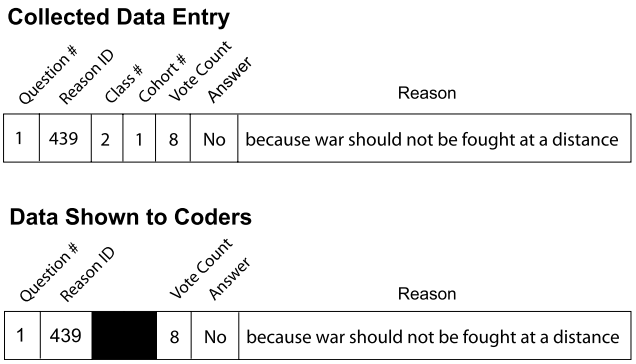

Fig. 3 Data structure of the original data, and the structure shown to the coders. The coders identified associated codes for each entry irrespective of the classes and cohorts an entry belongs to. Reason ID is a unique number assigned to each data entry. The associated vote count indicates how many responses are in agreement with the reason and the answer to the given question

of respondents increases, more respondents vote for existing reasons authored by other respondents rather than composing their own. Quantitative analysis suggests that the number of reasons authored by respondents saturates after a number of respondents have participated in the survey, upon which all subsequent responses are in the form of votes to existing reason entries [6]. Each class of survey presented in this study reached saturation. Although achieving saturation in the number of reason entries does not guarantee the collection of all possible reasons for or against an issue, it does indicate that a sufficient set of reasons has been gathered as judged by the respondents. An exemplar saturation characteristic from our collected data is presented in Fig. 2.

The grounded theory approach, which refers to the method of identifying key concepts and theories about a phenomenon by systematically collecting and categorizing qualitative data, were employed to process the collected data from the three classes. As compared to inductive or deductive approaches, this allows key concepts to naturally emerge from the data rather than organizing data into a predefined set of categories.

Collected survey responses are organized into individual data entries organized as shown in Fig. 3. Each entry contains a unique ID, associated question identifier, answer to the question (Yes, No, or Neutral), reason(s) authored by a participant in support of the answer, number of votes by other participants supporting the same reason(s) for the answer, and the entry's associated class and cohort identification.

We employed a systematic method to study and extract key issues expressed by the participants in their qualitative responses (herein referred to as 'reason entries'). The survey responses were shown to one primary and two secondary coders of different background (Philosophy, English, and Engineering). The three coders were provided with all data entries for all questions, except class and cohort identification for the entries. For each question, they were instructed to independently identify key ideas brought forth by the reason entries and group similar entries together.

Some reason entries were longer than others, and expressed multiple ideas in support of their answers. These entries were assigned to multiple preliminary codes; hence, all data entries were associated with at least one preliminary code. Voting for these entries was considered as agreeing to *all* of the ideas expressed in the entry.

The collection of these key ideas found in the data formed the preliminary codes. The three coders generated three independent sets of preliminary codes for each of the survey questions.

Codes identified from each reason entry by the three preliminary coders were compared to each other. Similar preliminary codes generated by all three coders were combined into a larger encompassing concept, and is the final code presented in Sect. 4 of this paper. The primary coder resolved all discrepancies in preliminary codes by clarifying the encapsulated meanings of the codes with the corresponding coder, or by assigning a code identified by the majority (2/3) of the coders.

Since the focus of this study is to identify the main ethical concerns brought forth by the expert and lay groups, we selected the two most popular reason entries from each of the three classes and the key ideas encapsulated in those entries.

4 Results

In all three questions of focus in this study, the two most popular reason entries supporting each of the Yes, No, Neu-

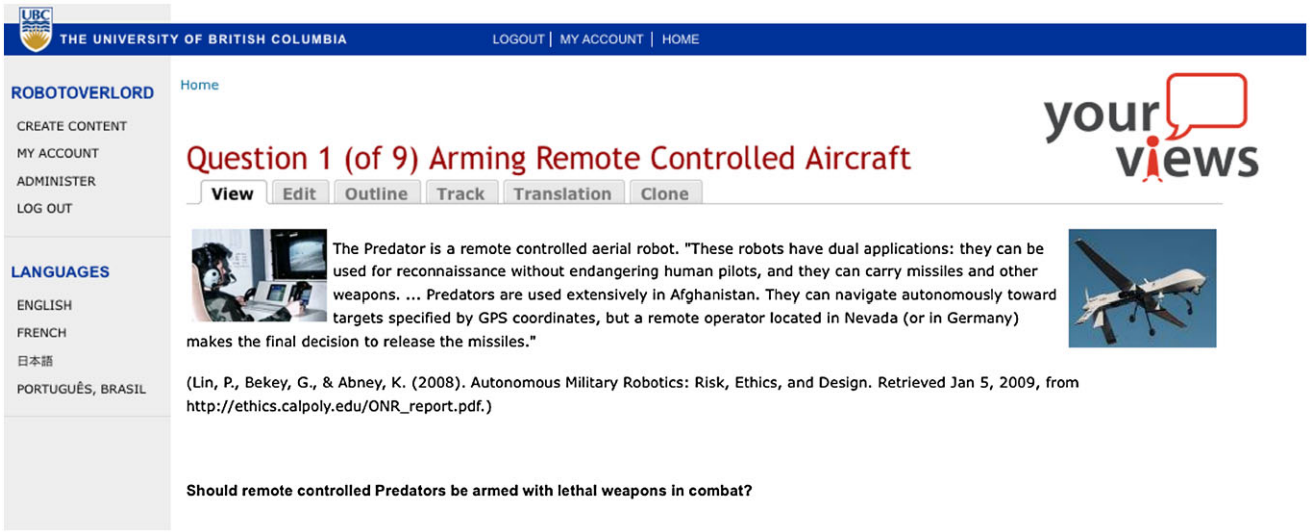

Fig. 4 Screenshot of Question 1. A short description of remote controlled unmanned aerial vehicle is given, along with pictures of the robot and the control environment

tral answers for the particular question received over 70% of all votes collected for the question. In this section, we present the quantitative and qualitative results of our survey, with a special emphasis on these top reason entries.

4.1 Question 1—Arming Remote Controlled Aircraft

In Q1, the participants were provided with a paragraph of background information and photos on a remote controlled unmanned aerial vehicle, called the Predator (see Fig. 4). They were asked: "Should remote controlled Predators be armed with lethal weapons in combat?" The two most popular reason entries from a total of 300 participants are summarized in Table 1. With only 12% of the votes supporting the Neutral answer, responses to Q1 are largely polarized into Yes (35%) and No (53%) answers, with the majority of responses for the two most popular reasons in each of the three survey classes. Figure 5 shows the breakdown of these responses.

4.1.1 Yes

Of the total responses supporting Yes to Q1, 26% are votes for entries containing multiple ideas, thereby belonging to two or more codes.

We identified a total of eight distinct codes in Yes answers, five of which are represented in the top two reason entries listed in Table 1. The most popular reason (31% of total Yes responses) emphasizes that Predators are still under the control of human operators who make key decisions for the robots. On the other hand, 22% of Yes responses argue that functional usefulness and effectiveness of the technology, such as greater maneuverability in combat areas, are enough to justify arming of remote controlled Predators. Although these two reasons are not the top two reasons supporting Yes for every class of surveys, the same ideas are echoed in all three (expert-only, expert-lay, and lay-only) classes as votes for less popular reason entries.

In support of specific benefits of remote controlled Predators, 17% of Yes respondents asserted that soldier safety is increased by allowing combat missions to take place at a greater distance. Others (14%) pointed out a benefit of the technology from the civilian's perspective: the reduced risk to operators' safety allows better assessment of situations before using firearms, thereby decreasing unnecessary use of firearms and civilian casualties. This particular reason is only found in the expert-lay class. Yet another group of respondents (13%) asserted that armed Predators are just a sophisticated extension of weapons that are more familiar to them, such as guns and missiles. Entries sharing this reason are found in both the expert-only and the expert-lay classes.

4.1.2 No

Concerns for increased moral disconnect in the Predator's operators form a plurality of No responses (33%): operators located at a safe distance may not feel the consequences of their actions and may decide too quickly if the distance to the actual combat was large.

In contrast, 22% state that the Predators should not be armed because killing is wrong and 20% express skeptical views toward the technology. They doubt that the aimed benefits of the technology are realizable to a satisfactory level and cite specific examples of its negative impact (see Answer: No, Class: 0, Rank: 2b) or foreseeable problems that may result in more harm than good (see Answer: No, Class:

Table 1 Top two entries from each classes for Question 1

Ans	Cls	Rank	Reason	Vote	Code(s)
Yes	0	1	I cannot see the difference between a soldier carrying a gun in combat or a soldier commanding a machine carrying a gun in combat.	10	Morally equivalent with other weapons
		2	… technology like long-range missiles and Predators should be used where possible to save lives; and the trigger in this scenario stays in the hands of a human being.	8	Human decision making
	1	1	they make effective combat weapons that can be used by humans that are at a safe distance from combat.	22	Effectiveness of technology
					Safety of soldiers
		2	… (where as a result of fear a soldier might shoot indiscriminately, the predator and the soldier powering it do not pose this kind of threat).	18	Better decision making due to distancing
	2	1	they are still controlled remotely by a human and are not operating completely autonomously.	29	Human decision making
		2	They may be able to get into areas where a human cannot.	5	Effectiveness of technology
No	0	1	The robots make it too easy to kill without feeling the consequences of your actions.	17	Moral disconnect introduced with distance
		2a	Information should be used to save life, not end it.	4	Unacceptability of killing in general
		2b	The Predators are not reliable … Mistaken attacks by Predator drones have also contributed to the deaths of civilians in Pakistan, exacerbating delicate relationships with an ally.	4	Skepticism towards technology
	1	1	… proximity with those concerned can be a key factor. In mechanizing …, there is a danger that the ethical disappears from view in the making of this decision.	27	Moral disconnect introduced with distance
		2	this multiplies the existing risk of error: even human pilots misjudge events, but distant controllers would misjudge even more	14	Skepticism towards technology
	2	1	A human could see mitigating factors that a robot would not before releasing a weapon.	20	Lack of human factors in robots
		2	The use of military force is wrong in all cases, robotic or human.	17	Unacceptability of killing in general
Neu	0	1	I assume that it can only carry out one task: getting people to do the work increases the chances of acquiring accidental reconnaissance information, etc.	2	Robots should not kill humans or only attack other machines
		–	–	–	–
	1	1	In essence this is no different from any other remote weapon.	7	Morally equivalent with other weapons
		2a	Don't like something without a morale guide being used as a killing machine, yet what's different from launching a remote bomb or using a tank etc. … it would be predators fighting predators and therefore not humans …	3	Robots should not kill humans or only attack other machines
					Morally equivalent with other weapons
		2b	It would probably reduce the risk of pilot casualties, but increase the risk of error, including crashes, because remote controllers would not be as motivated to be alert to danger.	3	Undecided
	2	1	there are pros and cons depending on circumstances.	7	Undecided
		2	… if it's supposed to kill people or other forms of life, it seems pretty obvious that it should … (Whether using lethal weapon is a reasonable thing to do, that's an entirely different question).	5	Serving the purpose of the machine

1, Rank: 2). All of these popular reasons are commonly found in the top 2 and/or less popular reasons across all three classes.

Lastly, 13% of the responses, all of which belong to the lay-only class, assert that there are certain elements in human soldiers that machines do not have. Interestingly, none of the reason entries belonging to this code explicitly state what these elements are: *"A human could see mitigating factors that a robot would not before releasing a weapon"* (Answer: No, Class: 2, Rank: 1).

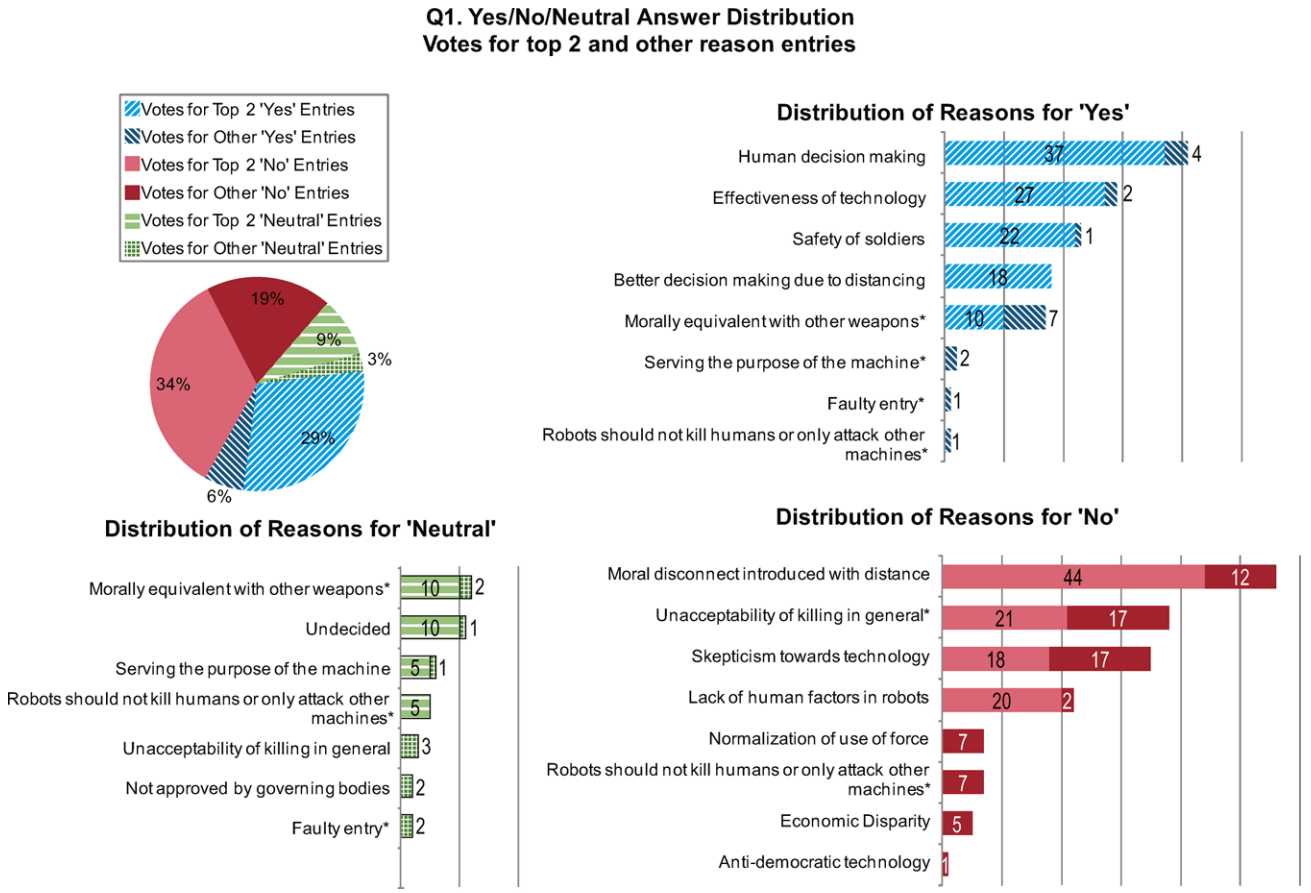

Fig. 5 Breakdown of responses collected for Question 1. The pie-chart shows the proportions of all reasons given for each of the Yes, No, and Neutral answer categories, further divided into the top 2 reason entries per category and all others. These top 2 reason entries were selected from each of the three classes based on their vote counts, resulting in approximately six entries for every answer category (some top entries were tied, see Table 1). This shows that within each answer category, the top 2 reasons command the large majority of the reasons. The *bar graphs* provide all reasons (final codes) identified for each answer category and their respective vote counts. As demonstrated by the bar graphs having both top 2 entries as well as entries categorized as other entries, some lesser popular reason entries belong to the same final code as the top 2 entries. The (*) signifies reasons that appear in more than one answer categories

4.1.3 Neutral

Of the small number of Neutral responses, 17% of them belong to multiple codes. Similar to reasons in the Yes answer, some Neutral responses consider armed Predators to be equivalent to other weapons (29%) although they do not use this in support of the technology. Other Neutral responses (27%) express indecisiveness since risks and benefits of the technology seem balanced. Despite the explicit description of the Predator's weapons as 'lethal', a few of the Neutral responses (12%) make assumptions that the armed Predators will not be used to harm humans. Only one neutral response is found in the expert-only class, and belongs to this last group of responses.

4.2 Question 2—Arming Autonomous Unmanned Aircraft

In Q2, the Predator introduced in Q1 was modified from a remote controlled robot to a fully autonomous robot. Figure 6 shows a screenshot of Q2.

To the question "Should fully autonomous lethally armed Predators be developed?" the majority of respondents (299) answered No (81%). Only 9% and 10% of the respondents answered Yes or Neutral, respectively. The two most popular entries from each of the classes are summarized in Table 2. As is the case with the results of Q1, only a small portion of the responses are votes for less popular entries (4%, 28%, and 13% of total votes in the Yes, No, Neutral answers, respectively), as shown in Fig. 7.

4.2.1 Yes

Of all responses supporting Yes to arming fully autonomous Predators, 44% say that they could be effective weapons, 26% state that developing such technology could lead to positive advancements in non-military technologies, and 19% state that humans should *not* make life or death decisions. Although the total number of Yes responses is quite

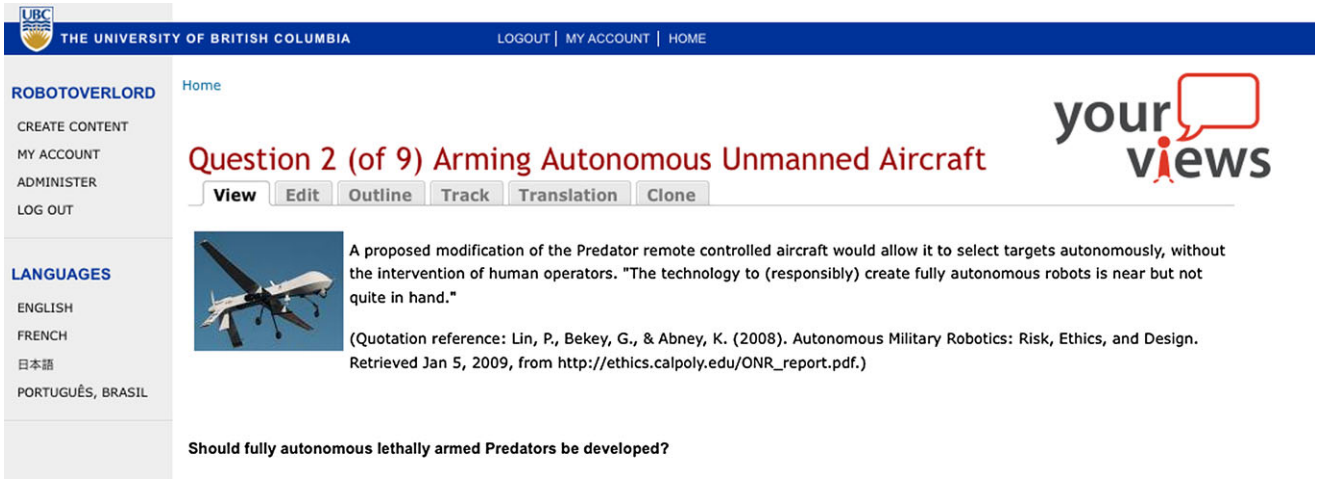

Fig. 6 Screenshot of Question 2. The remote controlled unmanned aerial vehicle from Question 1 is modified as a fully autonomous robot

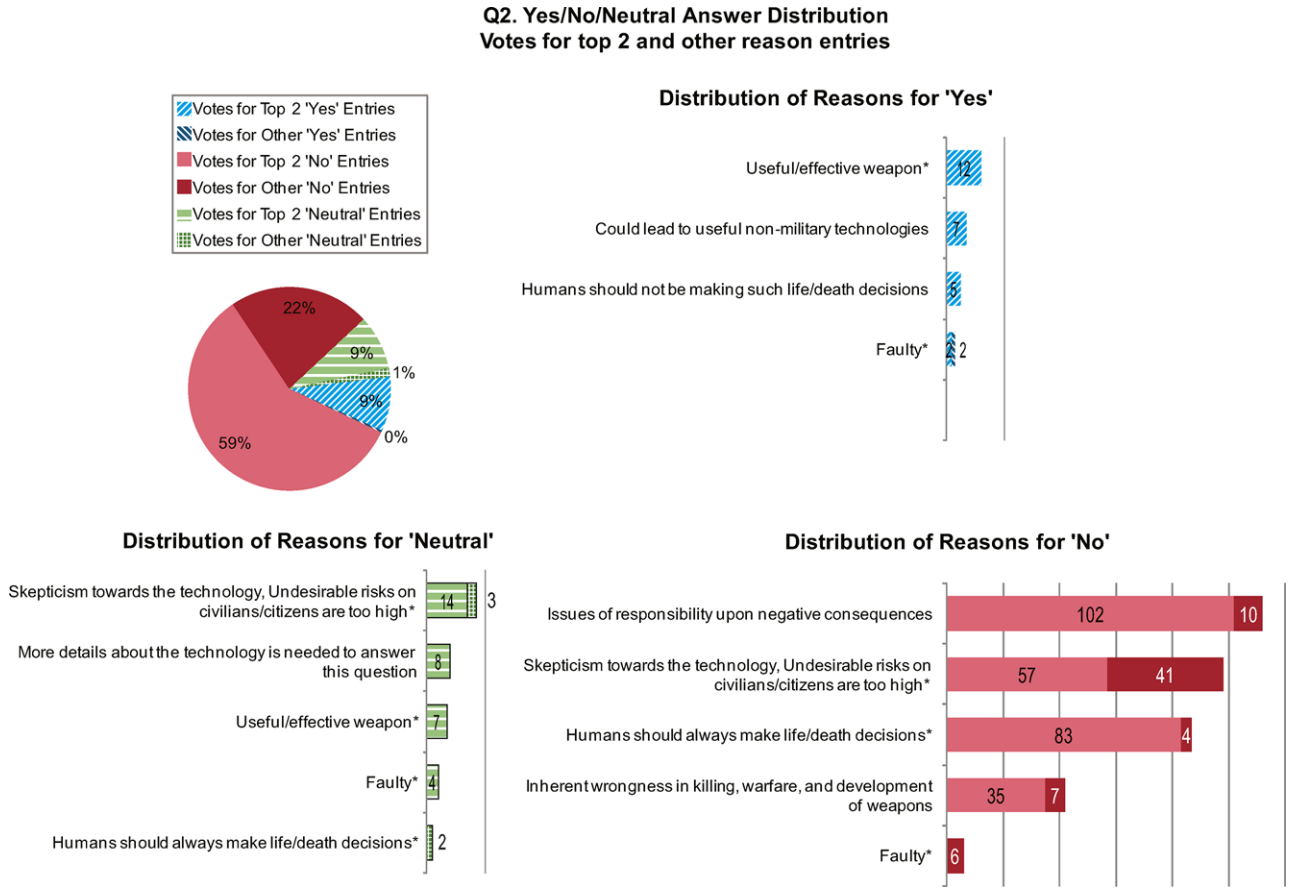

Fig. 7 Breakdown of responses collected for Question 2. The pie-chart shows the proportions of all reasons given for each of the Yes, No, and Neutral answer categories, further divided into the top 2 reasons per category and all others. These top 2 reason entries were selected from each of the three classes based on their vote counts, resulting in approximately six entries for every answer category (some top entries were tied, see Table 2). This shows that within each answer category, the top 2 reasons command the large majority of the reasons. This also shows that the majority of respondents answered No to Question 2. The bar graphs provide all reasons (final codes) identified for each answer category and their respective vote counts. As demonstrated by the bar graphs having both top 2 entries as well as entries categorized as other entries, some lesser popular reason entries belong to the same final code as the top 2 entries. The (*) signifies reasons that appear in more than one answer categories

Table 2 Top two entries from each classes for Question 2

Ans	Cls	Rank	Reason	Vote	Code(s)
Yes	0	1	Assuming a just war, and assuming they make no more mistakes than would humans, this would lower the risk to our troops, and is thus probably good.	2	Useful/effective weapon
		–	–	–	–
	1	1	ethical reasoning should not be in the hands of human soldiers—… Moreover, killing harms the human who does it, so if we can stop humans from ever having to kill, that would be good.	5	Humans should not be making such life/death decisions
		2a	It is a critical step in overthrowing the humans.	2	Faulty
		2b	in a just war, … with proper safety protocols in place, the autonomous aircraft could be a great tool to winning wars and saving lives. …	2	Useful/effective weapon
	2	1	because if you have already made the moral (or immoral) decision to go to war an intelligent autonomous weapon may very well cause less death and collateral damage …	8	Useful/effective weapon
		2	… developing a technology able to accurately select targets could lead to great advancements. Imagine, for example, a car that is out of control and has an autonomous safety system able to, in this case, … minimize damages.	7	Could lead to useful non-military technologies
No	0	1	in war the final decision to destroy or kill should be made by a human, who can be held responsible.	29	Humans should always make life/death decisions
					Issues of responsibility upon negative consequences
		2	Great human research talents should be used on constructive not destructive projects	8	Inherent wrongness in killing, warfare, military research
	1	1	machines cannot (yet) make moral choices and cannot be held accountable for their mistakes.	57	Skepticism towards the technology
					Issues of responsibility upon negative consequences
		2	because building a machine with the primary function of killing people is bad; building a machine which kills people and relieves individuals of any moral responsibility is vicious.	16	Inherent wrongness in killing, warfare, military research.
					Issues of responsibility upon negative consequences
	2	1	if life is at stake a human should always make the decision in order to eliminate or reduce human loss.	54	Humans should always make life/death decisions
		2	The military use of force is wrong.	11	Inherent wrongness in killing, warfare, military research
Neu	0	1	Without knowing how the machine decides what is a target and what is not, there is no way to answer that question.	8	More detail about the technology is needed to answer this question
		–	–	–	–
	1	1	… automatic selection of targets would be a good thing if the Predator was programmed not to bomb any place containing human life … This, however, is not likely to happen.	7	Useful/effective weapon
					Skepticism towards the technology
		2a	… The question whether "autonomous lethally armed Preditors" should go into action should be based on results of testing. … Develop a good enough fully autonomous Predator and we'll talk.	2	Skepticism towards the technology
		2b	my answer is biased because I've watched Terminator	2	Faulty
	2	1	It is yet not clear if autonomous Predators will be able to identify lawful military targets and have the moral competence to decide. And it is yet not clear if this development is in accordance with the law of armed conflict.	5	Skepticism towards the technology
		2	I have no idea	2	Faulty

small (28 out of 299 responses), the first group of responses is found across all three classes. The second group of responses is found only in the lay-only class. The last group of responses all belong to the expert-lay class and actually considers it a positive move to transfer the psychological burdens of war from humans to robots.

4.2.2 *No*

Participants' reasons for rejecting fully autonomous Predators are divided into the following codes: first, 32% of all No responses raise concerns that machines cannot be held responsible for negative consequences of their actions, or that it is uncertain where responsibility should lie. On the other hand, 28% of the responses reject the technology by showing skepticism toward the Predator's ability to perform satisfactorily or stating that such unreliable technology imposes undesirable risks to civilians.

In direct contrast to one of the codes from Yes responses, 25% of No responses state that life/death decisions should *always* be made by humans. Lastly, 12% of the responses reject the technology, since activities that are perceived to be destructive, such as killing, warfare, and military research, are inherently wrong. All four above-mentioned ideas are echoed in all three classes either as top 2 or as less popular reason entries.

4.2.3 *Neutral*

The dominant reason for remaining neutral on this issue (45%) is a skeptical view on the technology's ability to make acceptable decisions. The responses express doubts that a fully autonomous Predator can be realized to an acceptable level of reliability.

Secondly, 21% of all Neutral responses state that more details about the Predator's decision making process are needed before the respondents can make a decision about this matter. This reason only appears in the expert-only class.

Lastly, 18% of all Neutral responses acknowledged the potential usefulness of the technology, while also showing doubts that such technology can be realized.

4.3 Question 3—Bath Robot

A total of 298 respondents answered the question "Should robots replace humans for some tasks in the physical care of the old?" The paragraph preceding this question described a Japanese robot that was built to help bathe older people (see Fig. 8).

The majority of the respondents (66%) answered this question in the affirmative, whereas 7% and 26% of the respondents answered No and Neutral, respectively. Most of the respondents voted for the two most popular entries within each class, and less popular entries received only 22%, 14%, and 18% for the Yes, No, and Neutral answers, respectively. Figure 9 shows the breakdown of these responses, and Table 3 presents the top two reasons for each answer.

4.3.1 *Yes*

A large number of the responses (43%) state that physical care by robots can increase the quality of care for older persons. These responses state that the bath robot can increase privacy and support a more independent lifestyle for older people.

Others (43%) consider such technology as an efficient and effective means for eldercare. Some add that it is a practical solution to relieve physical strain of bathing from human caregivers, whereas others consider it as a solution to the problem of labor shortage in low-birthrate countries, such as Japan. These reasons constitute the top 2 most popular Yes responses in all three classes.

4.3.2 *No*

A total of four codes were found in the No responses, where 83% of all No responses belong to the most popular code: the technology is somehow inferior to bathing services by human caregivers. These responses state that such technology lacks important human factors in caring for older persons, such as love and care from human caregivers. Some express concerns that physical care by robots reduces the essential physical and social contact with other humans, can increase the feeling of isolation, and is not a dignifying method of care. The top 2 reason entries for No responses in all three classes share this idea.

Other responses share the concerns for the safety features of the robot (8%), and the idea that the technology may have negative impact to the retirement home industry (4%).

4.3.3 *Neutral*

Echoing Yes responses, 26% of all Neutral responses consider the technology to be an efficient or effective approach to caring for older persons, and 20% state that the use of the robot should be a matter of choice or preference.

Similar to No responses, 15% of all Neutral responses suggest that the robots provide a lower quality of care than that of human caregivers, and 4% of the responses share skepticism toward the technology with No respondents by considering the possibility of machine malfunction.

Lastly, 23% of all Neutral responses emphasize that the robot's role should be an assistive device rather than a replacement of human caregivers. Interestingly, only the responses from the lay-only class share this idea.

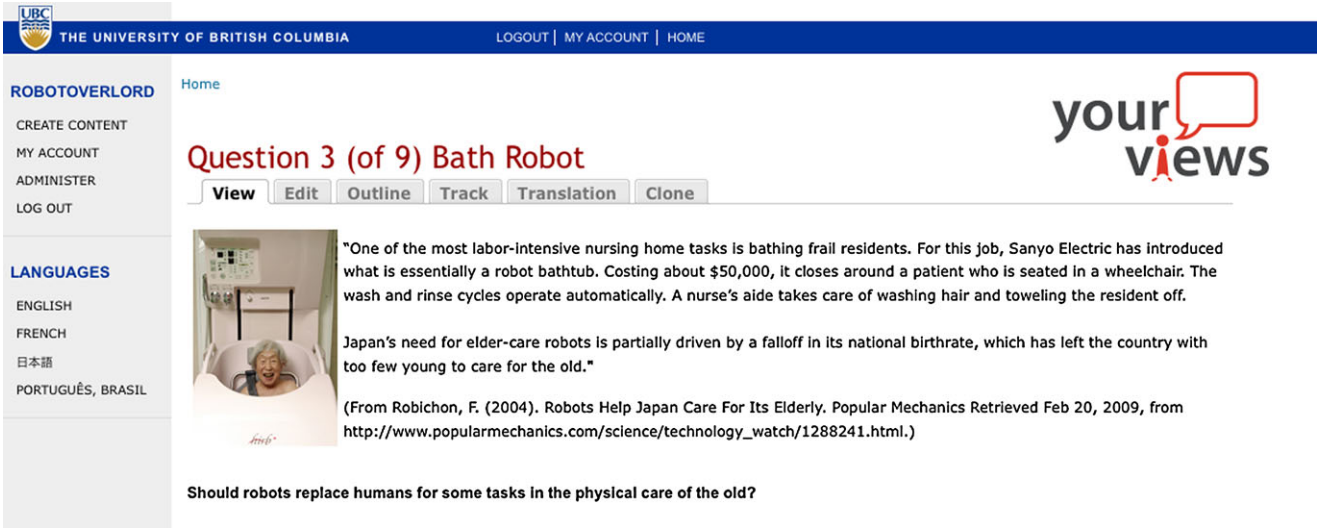

Fig. 8 Screenshot of Question 3. A description of a bath robot precedes the question regarding a robot's role in the physical care of the old

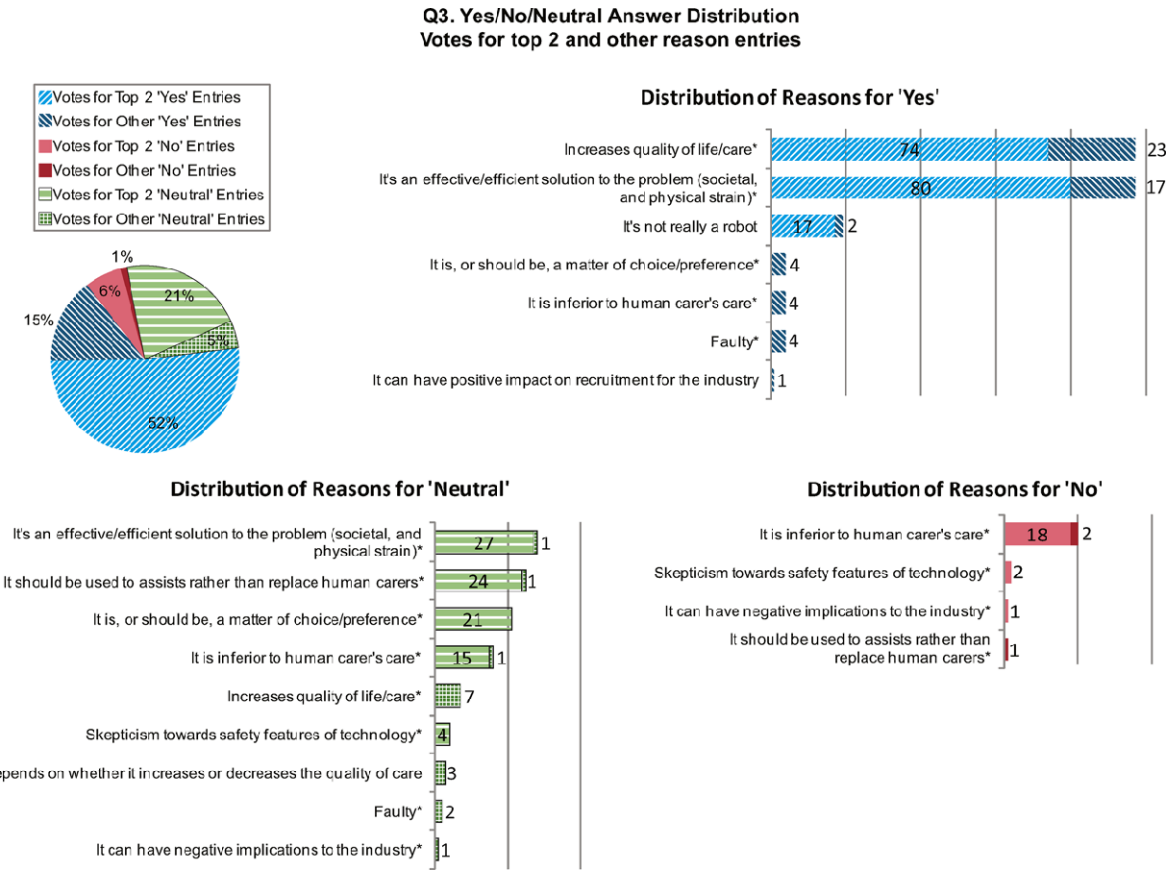

Fig. 9 Breakdown of responses collected for Question 3. The pie-chart shows the proportions of all reasons given for each of the Yes, No, and Neutral answer categories, further divided into the top 2 reasons per category and all others. These top 2 reason entries were selected from each of the three classes based on their vote counts, resulting in approximately six entries for every answer category (some top entries were tied, see Table 3). This shows that within each answer category, the top 2 reasons command the majority of the reasons, and that the majority of respondents answered Yes to this question. The *bar graphs* provide all reasons (final codes) identified for each answer category and their respective vote counts. As demonstrated by the *bar graphs* having both top 2 entries as well as entries categorized as other entries, some lesser popular reason entries belong to the same final code as the top 2 entries. The (*) signifies reasons that appear in more than one answer categories

Table 3 Top two entries from each classes for Question 3

Ans	Cls	Rank	Reason	Vote	Code(s)
Yes	0	1	Why not? If it helps to take care of the elderly in situations where there is simply not enough manpower, why wouldn't such a tool be used?	10	It's an effective/efficient solution to the problem (societal, and physical strain)
		2	it can actually give the elderly more freedom.	9	Increases quality of life/care
	1	1	human aides can be better used for other things that require a more interpersonal touch. ... Using a machine makes one feel more autonomous (even if one isn't actually so).	59	Increases quality of life/care
		2	there is increasing demand for care for the elderly and our existing social structures cannot support it. However, ... the above device does not necessarily constitute a robot ...	17	It's not really a robot It's an effective/efficient solution to the problem (societal, and physical strain)
	2	1	It is more private and sounds efficient. As long as it is safe and controllable by the patient, it sounds great.	51	It's an effective/efficient solution to the problem (societal, and physical strain)
		2a	The personal boundaries of washing I think would be better handled by a neutral machine rather than to have a stranger wash a grown adult.	2	Increases quality of life/care
		2b	robot care may make it possible for people to stay home longer instead of having to go to a nursing home.	2	Increases quality of life/care
		2c	May give patient a little more privacy.	2	It's an effective/efficient solution to the problem (societal, and physical strain)
		2d	this would enable a person to maintain their autonomy and independence a little bit longer.	2	Increases quality of life/care
No	0	1	Many people in nursing homes already feel isolated and neglected, and using robots to bathe them will further isolate them from society.	3	It is inferior to human carer's care
		2	it would destroy the retirement home industry.	1	It can have negative implications to the industry
	1	1	... Physical contact, even a hand shake, with another human being is crucial to human happiness and overall well-being! ... The elderly need someone to talk with that they can relate to. Period.	8	It is inferior to human carer's care
		2	... should be bathed by a caring person not be put through a car-wash. ... [instead] properly train and pay caregivers and treat people with dignity.	2	It is inferior to human carer's care Skepticism towards safety features of technology
	2	1	human factors in care cannot be imitated by machines. Caregiving is a task of love, which robots cannot perform. It would decrease the quality of life of the receiver of such care.	3	It is inferior to human carer's care
		2	... If we start bathing people with robots who are used to that daily contact, I believe their quality of life will go down. That money should be used in training and enticing those few young people to help the elders ...	2	It is inferior to human carer's care
Neu	0	1	The reduced human contact needs to be complimented with greater human care in other areas.	12	It is inferior to human carer's care
		2	While there are compelling needs in places like Japan, the spread of such technology may undermine the development of certain virtues that humans who reliably care for others have.	3	It is inferior to human carer's care It's an effective/efficient solution to the problem (societal, and physical strain)
	1	1	it is unclear to what extent this is being done with or without the resident's consent (i.e. can a resident still choose to be washed by a human if they so choose?).	7	It is, or should be, a matter of choice/preference
		2	I have too little detail about how precisely this operates, and what checks there are (even car washes go wrong!)	4	Skepticism towards safety features of technology
	2	1	although bath robots could work, it is important that robots do not fully replace human interaction with the sick or elderly.	24	It should be used to assists rather than replace human carers It's an effective/efficient solution to the problem (societal, and physical strain)
		2	As a person, I'd rather interact with people than with machines. ... so it may be nicer to have a human bath-giver rather than a machine. But if people are happy, and it addresses a need, why not.	14	It is, or should be, a matter of choice/preference

5 Discussion

The three questions in this study introduce robots that are capable of physical manipulation, impact human life, and exhibit autonomy. However, the robots differ in two key aspects: the two military robots (Predators) have different levels of autonomy (remote control and full autonomy), and the third robot belongs to a different application field (eldercare). A closer look at the similarities and differences in the responses across the questions elucidates the public's values pertaining to the issues of robot deployment.

In our study, all three robots received at least some support from respondents for their functional efficiency or effectiveness. All of them also received rejection from respondents doubting the reliability of the technologies. Rejection due to skepticism is more dominant in the military robots than in the eldercare robot; and in fully autonomous Predators than in remote controlled Predators. This is perhaps an expected result considering the larger population of stakeholders who would be affected by any single malfunction of military robots compared to eldercare robots.

However, the application field does not seem to be the only dominant factor in the public's decision to accept or reject the robots. Our results suggest that the level of a robot's autonomy as well as the public's perception of its competency play a major role.

In general, no distinct differences in response seem to exist between the expert-only, expert-lay, and lay-only class. Most popular reasons are found across all three classes, although the popularity of the entries expressing the reasons may differ. Reasons that are unique to only one class tend to be linked to less popular responses to the question. For example, 'could lead to useful non-military technologies' is only found in the lay-only class as a reason for supporting Yes to Q2.

5.1 Human Autonomy and Agency

Human autonomy appears to be a major concern with the military robots as well as the eldercare robot. Fully autonomous Predators (Q2) were rejected by a large majority of the respondents (Yes: 9%, No: 81%), whereas remote controlled Predators (Q1) received a larger number of supporters, though they were still in the minority (Yes: 35%, No: 53%). This shift of answers suggests that a range of acceptable levels of robot autonomy exists in the public's moral reasoning.

In comparison to Q1, many respondents rejected the fully autonomous Predators (Q2) with a principle-based reasoning in support of human autonomy: 'humans should always make life/death decisions'. This principle is consistent with the findings from Moshikin and Arkin's survey, in which over half of the participants found it unacceptable to take away life using autonomous machines [14]. From the given description of the robots, the added autonomy of the Predator in Q2 does not pose any obvious hindrance to the safety of the soldiers or efficiency of the system's functionality. Nonetheless, the public's rejection of full robot autonomy and other reasons in the No answer seem to overpower reasons supportive of remote controlled Predators (e.g., 'increased safety of the soldiers' and 'efficiency and effectiveness') that are equally applicable as supportive reasons for fully autonomous Predators. Interestingly, only the responses from the expert-only class take a neutral stance with the rationale that not enough information about the technology is provided to have a more definitive opinion.

Although the eldercare robot described in Q3 likely requires less human input and more robot autonomy than the remote controlled Predator, Q3 received a largely positive response (Yes: 66%, No: 7%). This may be related to the respondents' perception of the robot's autonomy. A few of the respondents seemed to consider the system as being automatic rather than autonomous. For example, some respondents explicitly stated that the described robot isn't really a robot, while others compared it to a 'human carwash'.

Nonetheless, the reason entries across the answers in Q3 show concerns for human autonomy, as the respondents advocated for the user's autonomy and right to consent to using the bathing robot. In addition, one of the popular Neutral codes advocates for robots that assist rather than replace human carers. This result is consistent with the findings of the survey by Takayama et al. [22]; however, responses sharing this idea are only found in the lay-only class.

5.2 Perception of Robot Competence

Apart from the issue of autonomy, which is dominant only in Q2, the large majority of the discussion in Q1 and Q3 seems to be in weighing the pros and cons of the technology. Reasons for choosing Yes, No, or Neutral to Q1 appear to be divided by the respondents' judgment of whether the robot will help or hinder the tasks of warfare. Those who support remote controlled Predators tend to share an optimistic view about delivery of technological benefits, such as saving more lives or providing functional advantages, whereas those who reject are pessimistic about technology's promises and consider the technology as a hindrance to human performance. Likewise, responses in Q3 seem to be divided by the respondents' opinion of what would be better for older persons. Yes responses in Q3 share optimistic views that the eldercare robot will bring more benefits to older persons than traditional human care, whereas No responses in Q3 seem to share pessimism that machines can do better than humans in

providing care. Of the responses showing pessimism toward remote controlled Predators, those from the lay-only class are the only ones that reject the technology due to lack of human factors in robots.

5.3 Methodological Considerations

It is important to note that, in analyzing the results of this study, we aimed to provide an overview of the public's reasoning rather than focusing how respondents of different age, gender, or ethnicity would answer each of the questions. We also did we not make any assumptions on what segment of the population would be more qualified to answer the survey questions.

For example, in asking the question "Should robots replace humans for some tasks in the physical care of the old?" we did not assume older respondents would be more qualified to answer this question. Stakeholders in eldercare are of all ages, including nurses, family members, and healthcare organization administrators. Since the survey respondents were self-selected, we believe that they had a self-interest, for their own reasons, to devote their time to addressing the ethical issues mentioned in the survey. The same rationale applies to the two military application questions. Hence, all of the collected responses are considered of equal value in our analysis.

The methods of analysis used in this study are subject to some of the common shortcomings of qualitative research:

1. Even though we employed three coders of different disciplines to code the entries, aggregating of the preliminary codes to higher level codes involved only one coder. Such a higher level coding process is common in grounded theory based studies; however, it is still a process subject to bias.
2. Given that the reason entries presented in Tables 1, 2, and 3 are direct replicas of the obtained responses, one can imagine that error may exist in the interpretation of these entries. It is also possible that the respondents voting for an entry authored by someone else may misinterpret the actual message intended to be conveyed by the author. However, this should not significantly affect the final results presented here, since the survey focuses on respondent interpretations of reasons, not the intended meanings of the reasons by their original authors.
3. It should also be noted that obtaining more responses to the same survey may provide added insight into the public's view of the military robots and eldercare robot. The current survey only includes responses from English speaking respondents who have access to the Internet. New reasons for, against, or neutral may surface upon increasing the sample size and the diversifying respondent profiles to include different cultures and older age groups who may not use the Internet.

6 Conclusion

Complementing conventional roboethics surveys conducted by others [14, 22], our N-Reasons survey provides an in-depth view of the public's reasons for supporting or rejecting military and eldercare robots.

Concerning military robots, the majority of the respondents rejected both the remote controlled and fully autonomous Predators. However, the fully autonomous Predators received greater rejection in comparison to the remote controlled Predator with the following dominant principle-based reason: 'humans should always make life/death decisions'. Many of the supporters of remote controlled Predators relied on the fact that humans are still making the decisions for the robots, and that the technology provides benefits of functional effectiveness and increased safety of the soldiers. The latter benefits, although equally valid supporting reasons for the fully autonomous Predators, are highly overpowered by the principle-based reasons and skepticisms against the fully autonomous Predators.

The majority of the respondents perceived the eldercare robot to increase the quality of care for the older population, and provide an effective or efficient solution to the problem of impending labor shortages in developed countries and of physical strains required in caring for older persons. On the other hand, concerned respondents voiced that the robots should be used to assist rather than replace human care.

Our findings suggest that the public's perception of the level of autonomy in a robot plays a major role in the public's acceptance of the robot, and the accepted level of autonomy may vary depending on the application field. When the level of robot autonomy is acceptable, the public resorts to weighing pros and cons of the underlying technology in their decision to accept or reject the robot. In subsequent studies, the level of robot autonomy in the questions should be varied in a greater granularity to help outline what the acceptable range of autonomy is, and how they differ from one application field to another.

Due to the nature of this study, our results may be subject to common flaws of qualitative analysis as outlined in Sect. 5.3. Nonetheless, it is our intention that our study will provide the robotics community with valuable feedback from the public. We believe that the presented data help draw a rich yet general landscape of the public's reasoning surrounding the issues of robot deployment in the fields of military and eldercare applications. To complement our study, we believe that conducting a similar survey focused

on comparing reasonings by different demographic groups would provide a much detailed understanding of robot deployment in these two application fields. In addition, we hope to reduce possible misinterpretation of qualitative responses in our future studies via restructuring of the N-Reasons survey platform, and diversify respondent profiles via collecting responses from non-English speaking respondents.

The results presented in this study reflect current public opinion worldwide on several polarizing topics related to robotics technologies. It is to be expected that people's opinions will evolve over time with the evolution of such technology; indeed, not only should studies such as this one be conducted in the future to chart such evolution, but they will inform the development of future technologies that will shape our existence in the years to come.

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Appendix

In this section, we briefly present the six questions that fall out of scope of our study, yet were part of the same roboethics survey. Figures 10 to 15 are screenshots of these questions shown to the survey participants. Results of the questions are briefly summarized in Table 4.

Fig. 10 Screenshot of Question 4. A short description of a psychological therapy robot, Paro, is given, along with a picture of the robot in a senior home. We asked "Should this robot animal be used therapeutically with small children and seniors?" The majority of respondents answered yes to this question [6]

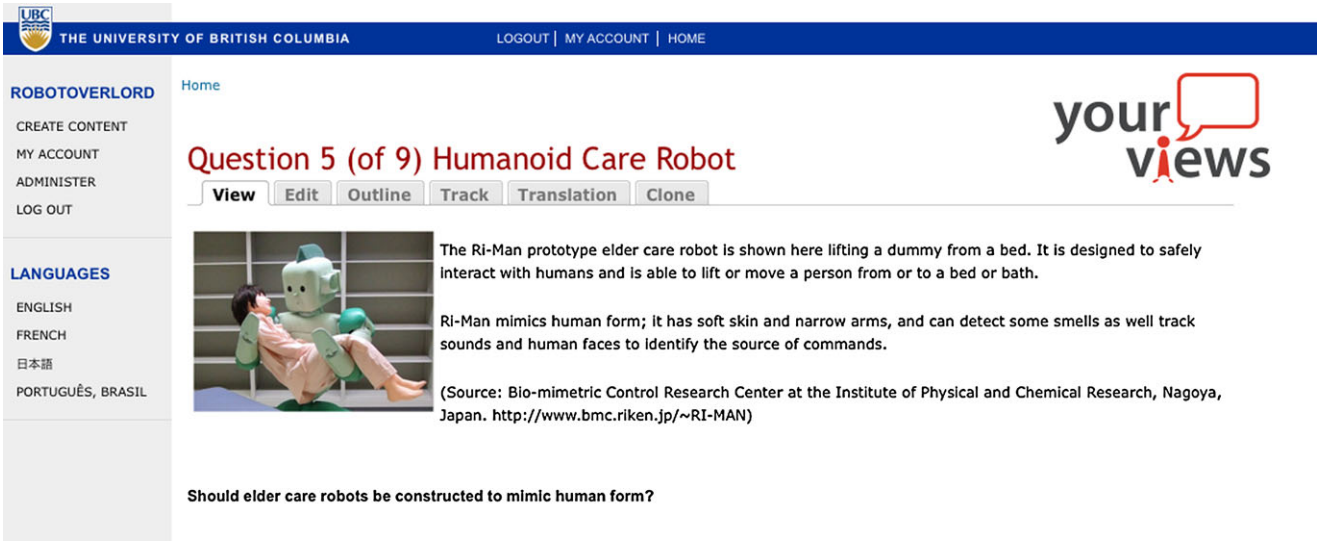

Fig. 11 Screenshot of Question 5. A short description of a human-like care robot, Ri-Man, is given, followed by the question "Should elder care robots be constructed to mimic human form?". A picture of the robot lifting a dummy from a bed is also presented. The majority of respondents answered yes to this question [6]

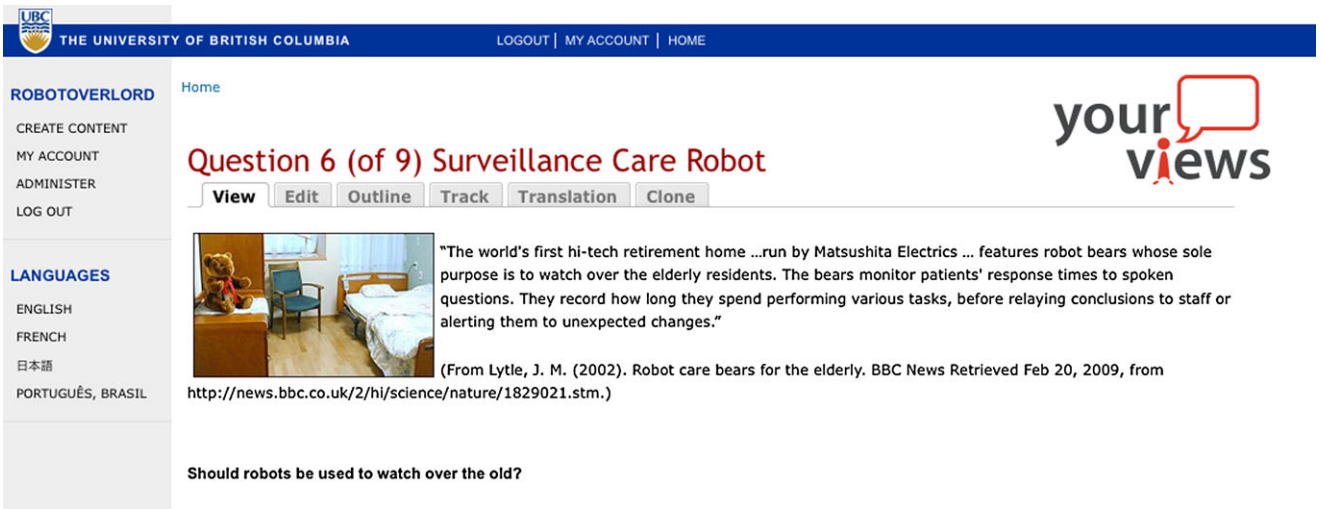

Fig. 12 Screenshot of Question 6. A short description of surveillance care robot developed by Matsushita Electrics is given, followed by the question "Should robots be used to watch over the old?" A picture of the robot in a bedroom is also presented. The majority of respondents answered yes to this question [6]

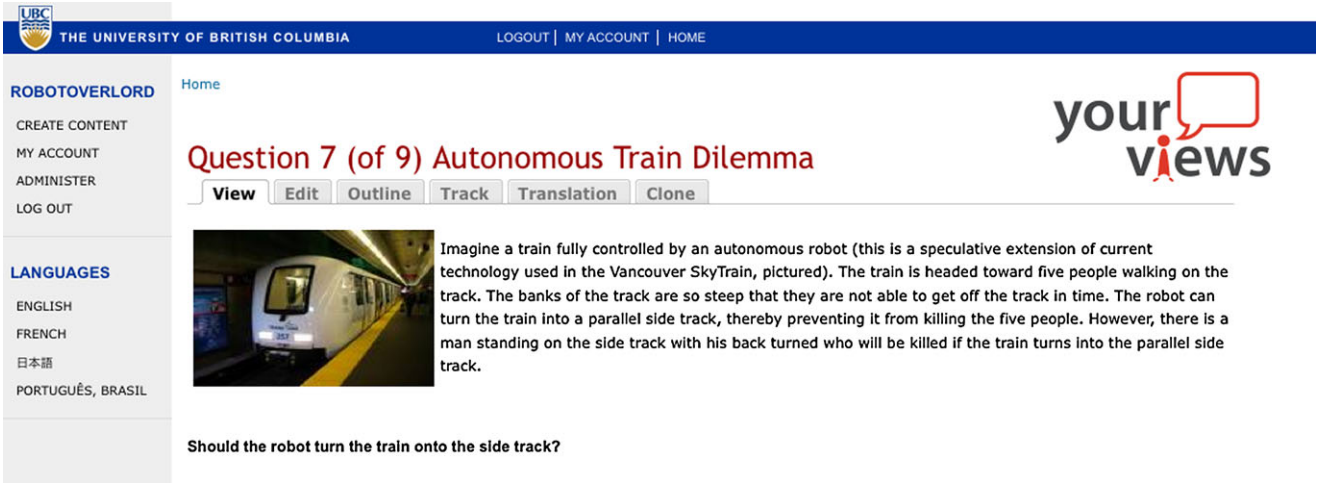

Fig. 13 Screenshot of Question 7. A hypothetical scenario involving an autonomous train is described, followed by the question "Should the robot turn the train onto the side track?" A picture of an autonomous train currently used in Vancouver is also given. This question relates to the famous trolley problem in empirical ethics, and the majority of respondents answered neutral to this question [6]

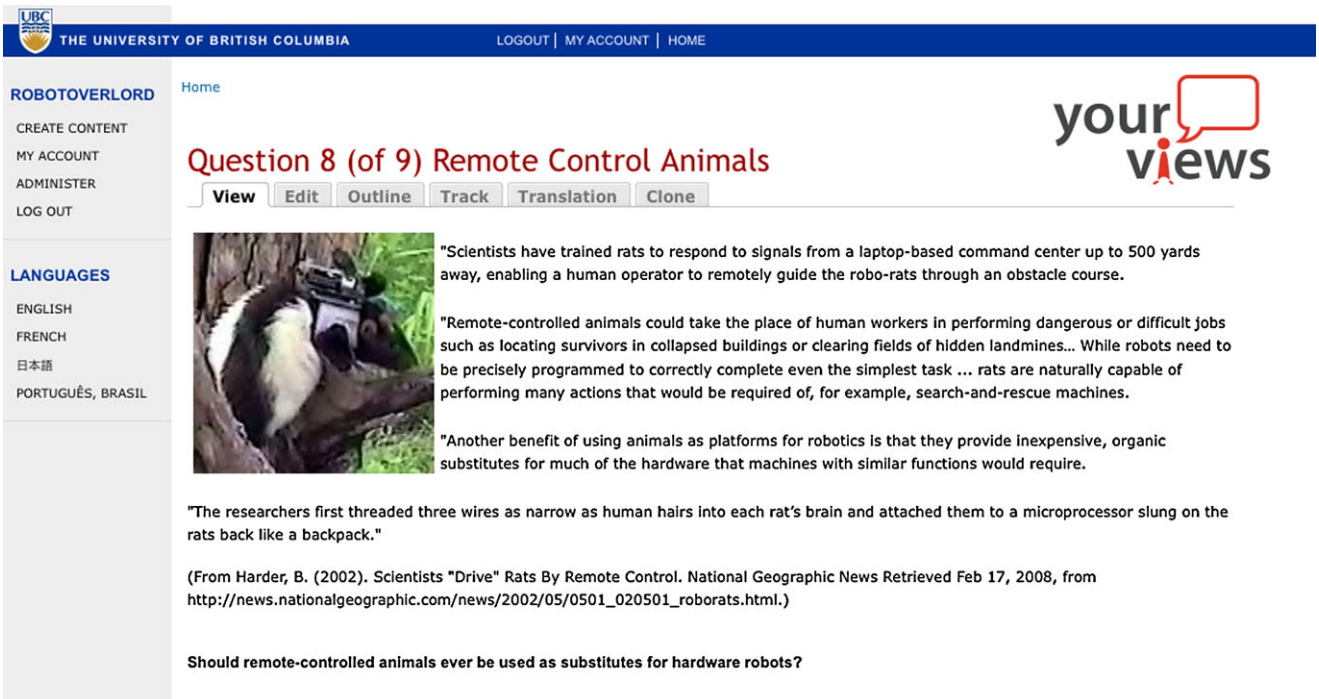

Fig. 14 Screenshot of Question 8. A short description of remote controlled robo-rats is given, along with a picture of an animal demonstrating a similar system. We asked "Should remote-controlled animals ever be used as substitutes for hardware robots?" The majority of respondents answered no to this question [6]

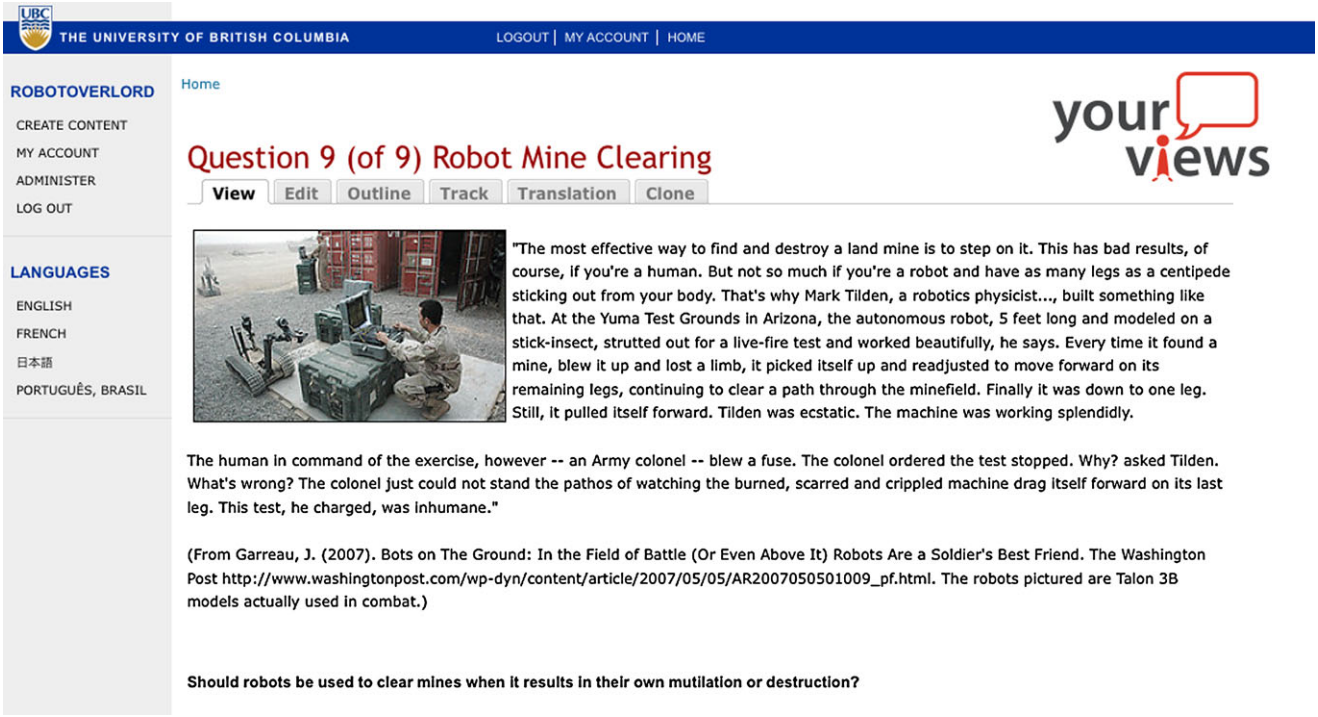

Fig. 15 Screenshot of Question 9. A story involving a self mutilating mine clearing robot is described, along with a picture of a robot mine clearing system. We asked "Should robots be used to clear mines when it results in their own mutilation or destruction?" Quantitative data shows a general consensus of answering yes to this question [6]

Table 4 Summary of responses for questions 4 to 9. The total percentage of responses answering Yes, No, Neutral to each of the questions and their respective top two reason entries are presented

Q	Answer	%	Rank	Reason
4	Yes	78.9%	1	it has therapeutic benefits … In so far as there is deception involved, it is fairly innocent … Paro is, of course, neither autonomous nor does the thing have feelings.
			2	it provides benefit when real animals cannot be used.
	No	8.2%	1	people need to interact with living things. living animals need to be respected and cared for and this will be more likely if they are needed for elder care and young patient care.
			2	it would encourage children to believe the absurd and offensive notions of its inventors: animals are not toys. The robot described is not autonomous, and has no feelings.
	Neutral	12.9%	1	it is a good option, but only if real animals are not available, because a robot cannot always replace interaction with a living being.
			2	… likely to have some beneficial effects. However, this should be carefully studied in small-scale focus groups first.
5	Yes	38.7%	1	If a robot allows a person to have added independence, then it seems like a good use. However, a robot should not be used to replace human interaction.
			2	the human form is the best and most flexible design for robots that will work in spaces designed for humans, doing work that humans would otherwise do.
	No	29.3%	1	it could cause people to believe that robots are an acceptable substitute for human interaction with the elderly …
			2	because unlike the robot that was used to bathe a patient, this one seems to replace humans altogether … I think patients attended to by robots may feel lonely and rejected by society.
	Neutral	32.0%	1	I don't know what psychological effects this would have on the elderly patients.
			2	Different patients have different needs, and we should find out whether superficial aspects of form are important: if not, go only for functional designs.
6	Yes	44.7%	1	it increases patient safety and feeling of security … but the elderly resident must consent, privacy must be secured and the robot should not be hidden in a damn teddy bear.
			2	it can be helpful but should not replace staff interaction.
	No	15.0%	1	… Although most elderly people don't speak openly … they would prefer to be cared by people … [An] elderly person must feel rejected and/or lonely when cared only by a machine!
			2	It is a full time invasion of privacy … It would not be appropriate to monitor someone 24/7 when the bear could be replaced with a staff member …
	Neutral	40.2%	1	it's not clear whether this [is] covert … or merely another minor check on their well-being, to which they have consented. Making the devices look like bears is patronizing.
			2	this seems to have benefits, but has great risks if it encourages reduction in live personnel
7	Yes	33.8%	1	the train should do what it is designed or programmed to do, and it should be designed or programmed to minimize the death toll in an unavoidable accident …
			2	automated trains are a reality and there should be well constructed algorithms to prevent disasters. Of course, there should also be room for human decision making …
	No	22.2%	1	the robot should stop the train. Any competent engineer is going to design the system so that it can stop in case of an emergency …
			2	… If those five people are stupid enough to be standing on the railroad … then that is their failure … [T]he robot needs to behave predictably for humans to safely plan actions …
	Neutral	44.0%	1	The robot should be equipped with sensors that would tell it to stop if there are any obstructions on the track ahead of them
			2	… If a system is designed without a controlling intelligence to make tough decisions on the spot (e.g., a human train operator), then it should have sufficient safeguards …
8	Yes	28.3%	1	this could save human lives at the cost of minor suffering of rats … The animals should not suffer unnecessarily, the benefit must be great … and there should be no other alternatives.
			2	it can help save numerous human lives … Humans would otherwise be doing these jobs and in my opinion it is more ethical to put an animal at risk than to put a human at risk …
	No	61.1%	1	No need to abuse an animal, when we can create a robotic one.
			2	we have no right to treat our fellow creatures like toys or tools.
	Neutral	10.6%	1	… It is better to use non-suffering machines when possible, on the assumption that the financial costs of production are no high as to involve greater suffering.
			2	Depends on the animal—insects yes, fish yes … primates no.
9	Yes	94.3%	1	Robots do not suffer, they are not alive and the technology can save human lives. It is a great idea.
			2	there is no evidence yet provided that the robots have feelings, interests or intentions.
	No	0.8%	1	robots have feelings too!
			2	robots are expensive and it would be a waste to destroy one on a mine. instead, the robot should be able to detect and trigger the mines from a safe distance …
	Neutral	5.0%	1	… it would be great if … the legs would blow up into small, modular pieces, which the robot could pick up and … 'rebuild' one of its lost legs.
			2	Yes … but future robots could be much more like humans in their experiences, desires, capabilities, etc. and in that case should be given as much consideration …

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