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Octagon Measurement: Public Attitudes toward AI Ethics

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ABSTRACT



Artificial intelligence (AI) is rapidly permeating our lives, but public attitudes toward AI ethics have only partially been investigated quantitatively. In this study, we focused on eight themes commonly shared in AI guidelines: “privacy,” “accountability,” “safety and security,” “transparency and explainability,” “fairness and non-discrimination,” “human control of technology,” “professional responsibility,” and “promotion of human values.” We investigated public attitudes toward AI ethics using four scenarios in Japan. Through an online questionnaire, we found that public disagreement/agreement with using AI varied depending on the scenario. For instance, anxiety over AI ethics was high for the scenario where AI was used with weaponry. Age was significantly related to the themes across the scenarios, but gender and understanding of AI differently related depending on the themes and scenarios. While the eight themes need to be carefully explained to the participants, our Octagon measurement may be useful for understanding how people feel about the risks of the technologies, especially AI, that are rapidly permeating society and what the problems might be.

1. Introduction

Artificial intelligence (AI) is rapidly permeating society, but people have concerns about the use of AI. In a study by the Pew Research Center, 979 experts were asked to consider whether AI will enhance human capabilities by 2030. Their concerns about AI were summarized in five points (human agency, data abuse, job loss, dependence lock-in, mayhem) (Anderson et al., 2018). Regarding job loss, one study analyzing 701 occupations in the US reported that 47% of workers are employed in jobs that will be replaced by AI over some unspecified number of years (Frey & Osborne, 2017). In a survey targeting 14,000 people from all over the world, they agreed they have concerns about the availability of future work (61%), and the regulation of AI to protect jobs (58%) (Carrasco et al., 2019). Also the public has concerns with regard to the regulation of AI. According to a global survey targeting 20,107 adults from 27 countries, 40% of the respondents agreed that the use of AI should be more strictly regulated by governments and 48% agreed that the use of AI should be more strictly regulated by companies (Ipsos, 2019). Carrasco et al. (2019) found in a global survey that 32% of the respondents answered that significant ethical issues had not been resolved as of today and 25% were concerned about the potential risk for bias and discrimination about the use of AI by governments.

It was found that public attitudes toward AI varied depending on several variables, including country, age,

gender, and education. In the US, 44% of respondents in one survey said the development of AI has mostly been “bad” for society and 47% responded that AI was “a good thing” for society. People in Asia-Pacific countries (Singapore, South Korea, India, Taiwan, Japan, Malaysia, and Australia), according to one survey, think that AI has a positive effect on society. One example: in Singapore, 72% thought that the development of AI has mostly been a good thing for society, while 16% said that it was a bad thing for society (Funk et al., 2020). In Japan, 65% said that AI was good and 18% said it was bad (Funk et al., 2020). Other studies have supported that age, gender, income, and education influenced attitudes toward AI (Albarrán et al., 2020; Araujo et al., 2020; Funk et al., 2020; Zhang & Dafoe, 2020). Men more often than women, as well as younger adults and people with more education in many countries were more likely to agree with the idea that the development of AI was a good thing for a society (Funk et al., 2020; Zhang & Dafoe, 2020). One exception was Malaysia: older rather than younger Malaysians saw AI as having a positive effect on society (Funk et al., 2020). AI-related knowledge (computer programming, AI, and algorithms) also influenced their perceptions. People who answered that they have knowledge of AI perceived the usefulness of AI more than those who did not (Araujo et al., 2020). At the same time, general interest in science and technology (S&T) affected perceptions of AI. In Spain, people with an interest in scientific

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discoveries and technological development saw AI and robots as useful (Albarrán et al., 2020). These studies suggest that AI-related knowledge and interest in S&T, in addition to basic variables such as age, gender, and education, contribute to people's perceptions of AI. These variables might also influence attitudes toward AI ethics, but this has been less well explored.

In recent years, various stakeholders around the world, such as governments, civil societies, the private sector, and intergovernmental agencies, have published guidelines on AI. Hagendorff (2020) analyzed 22 of these guidelines and reported that three themes ("accountability," "privacy protection," and "fairness, non-discrimination, justice") were mentioned in over 80% of the guidelines. Ema (2017) reviewed 10 guidelines published from late 2016 to 2017, including three guidelines from Japan: *AI nettowāku ka no eikyō to risuku* (Ministry of Internal Affairs and Communications, 2016), *Jinkōchinō to ningen shakai ni kansuru kondankai hōkokusho* (Cabinet Office, n.d.), and the *Japanese Society for Artificial Intelligence Ethical Guidelines* (Japanese Society for Artificial Intelligence, 2017). Fjeld et al. (2020) reviewed 36 guidelines, including two guidelines from Japan: *Social Principles of Human-Centric AI* from the Government of Japan (Social Principles of Human-centric AI, Cabinet Secretariat, n.d.) and *G20 AI Principles* (G20, 2019). This study identified eight common key themes in AI ethics shared in guidelines around the world: "privacy," "accountability," "safety and security," "transparency and explainability," "fairness and non-discrimination," "human control of technology," "professional responsibility," and "promotion of human values."

A range of attitudes toward AI have arisen in different contexts. One study targeting more than 14,000 Internet respondents showed that they supported the use of AI for the optimization of transportation, traffic, public infrastructure, and customer service, but did not support the use of AI for systems of justice (Carrasco et al., 2019). Also, people are likely to agree to the use of AI for analyzing big data for the fields of astronomy, law, and pharmacology, but are unlikely to agree to the use of AI for medical treatments and psychological counseling where sensitive human judgments are required (Schepman & Rodway, 2020). One study from the Netherlands investigated public perceptions of automated decision-making (ADM) by AI within the contexts of the media, health, and judicial systems, focusing on their usefulness, fairness, and risk. People answered that ADM was more useful than decisions made by human experts within the health context (Araujo et al., 2020). In Japan, one study suggested that people considered that issues requiring a social consensus (for example, driving, disaster prevention, and military activities) could be left to AI, but issues requiring personal decisions (such as life events) could not be left to AI (Ema et al. 2016). One of the areas in Japan where people expected the use of AI was healthcare (Miraikan, n.d.; PR Times, 2017). People's attitudes toward AI depend on the context and purpose (why it is being used). Therefore, it was important in our study to identify the aspects of AI that the public is concerned about by comparing attitudes across multiple scenarios.

2. The current study

We investigated public attitudes toward AI ethics focusing on the eight global themes ("privacy," "accountability," "safety and security," "transparency and explainability," "fairness and non-discrimination," "human control of technology," "professional responsibility," and "promotion of human values") developed by Fjeld et al. (2020). We call this the Octagon measurement, and conducted a scenario-based online survey in Japan using it. Common AI technologies, such as machine learning, are shared within many contexts, but the way AI is used varies with the context (Stone et al., 2016). We focused on four contexts and created the four scenarios: AI-generated singing (scenario "singer"), AI customer service (scenario "service"), AI unmanned weapons (scenario "weapon"), and AI prediction of criminal activity (scenario "crime"). The public attitudes were measured for each scenario. This scenario-based survey captures uniformly different attitudes toward AI and identifies which aspects of AI ethics the public feel should be considered more than is currently being done.

The first scenario (scenario "singer") uses AI to replicate the voice of a deceased famous person. This scenario is based on events that took place in Japan in 2019. A famous singer, Misora Hibari, who died in 1989, was "revived" as the AI-generated singer "Misora Hibari" (AI-MH). Her singing voice was reconstructed by AI from her real voice. AI-MH can perform vocally and give a short message to the public as a part of a song as if she were alive. Her performance was broadcasted on a well-known music TV program. People who watched the TV program had varied responses. In a survey in 2020, about half of Japanese people disliked using AI technology for "resurrecting" dead people (Miraikan, n.d.), though this was not limited to the AI-MH case. There is still a debate on the appropriateness of conducting a business without receiving approval from the singer while they are alive. Some people said that this project could harm the reputation of the singer (e.g., Yamagata Biennale, n.d.).

The second scenario (scenario "service") involves the use of AI for customer service. Today, many companies are collecting customer information with AI and using it for marketing. Examples of this type of marketing are the recommendation systems used by Amazon, Netflix, and others where customers can find a product of interest simply by visiting a website. On the other hand, there is the ethical question of the validity of unwittingly guiding customer behavior and preferences based on corporate intentions. One survey indicated that over 50% of Japanese people feel anxious about the use of personal data. Those people who are older and unfamiliar with big data are especially likely to have a negative attitude (Hakuhodo, 2019). This study also pointed out that many Japanese people are concerned about privacy issues. One of the reasons for their anxiety is that the transparency an AI judgment is still unclear (Hakuhodo, 2019). The issue of privacy is an ongoing field of research (e.g., Ji et al., 2015).

The third scenario (scenario "weapon") is the use of AI for unmanned weapons that can act autonomously. By introducing AI, we could remove combatants from dangerous

operations and reduce casualties. We may even be able to attack with greater deadly force than with human combatants. On the other hand, there is the ethical question of AI being used to kill people as well as discussions of legal liability if something goes wrong. Many AI and robotics researchers have signed an open letter declaring, “Starting a military AI arms race is a bad idea, and should be prevented by a ban on offensive autonomous weapons beyond meaningful human control” (Future of Life Institute, *n.d.*). Ema (2017) pointed out that AI guidelines from Japan seldom mentioned the use of AI in the development of autonomous weapons.

The fourth scenario (scenario “crime”) is the use of AI for preventing criminal activities. If we analyze peoples’ activities from databases containing information, for example, from personal credit card use, security cameras, etc., we might be able to predict criminal activities such as theft or murder with a high degree of accuracy. With further research, it might be possible to prevent various crimes and to limit the activities of people who might commit a crime. A survey reported that 70% of Japanese people who responded answered that AI is desirable for advanced analysis of indicators of crime that were linked to surveillance camera images and information from witnesses who suspected that a crime could take place (Hosotsubo et al., 2020). On the other hand, the appropriateness of using personal information for monitoring people and limiting the rights of people based on AI predictions is under debate. Improving fairness and minimizing the discrimination of these types of predictive algorithms is an ongoing field of research (Adebayo et al., 2015).

3. Research questions

We investigated public attitudes toward AI ethics focusing on the eight themes (“privacy,” “accountability,” “safety and security,” “transparency and explainability,” “fairness and non-discrimination,” “human control of technology,” “professional responsibility,” and “promotion of human values”) in four different scenarios. The level of public agreement/disagreement with AI and anxiety over AI ethics were investigated using a scenario-based online questionnaire. This study was conducted in Japan.

RQ1: How do attitudes toward AI ethics vary depending on scenarios measured by the eight themes?

RQ2: How are the variables (gender, age, education, interest in science and technology (S&T), and understanding of AI) related to attitudes toward AI ethics?

4. Materials and methods

4.1. Respondents

We conducted an online questionnaire to collect public responses. The authors contracted INTAGE Inc, a research company in Japan, to collect the data using their data pool. The company sent an e-mail to Japanese people who registered online. We collected data from 1,029 respondents (men = 519, women = 510) aged 20 to 69. These samples matched the current demographic profile of the Japanese population by age, gender, and location (Appendix A). All

responses were used for analysis. The survey was conducted from September 10 to 14, 2020 in Japan and received approval from the Institutional Ethics Committee of the University of Tokyo (no. 20-153).

4.2. Procedure

4.2.1. Questionnaire items

The online questionnaire consisted of variables (1, 2, 3) and the items for each scenario (4).

- (1) Age, gender, location, marital status, occupation, household income, number of children, education, political party supported, and time spent on PC/smartphone were asked.
- (2) Interest in science and technology (S&T): A method of Victorian Segmentation (VSEG) was used to classify the level of interest in S&T (Goto et al., 2014; Victorian Department of Innovation, Industry and Regional Development, 2011). VSEG consists of three questions (ST_Q1-ST_Q3).
 - ST_Q1. How much are you interested in science and technology? (A1: Very interested, A2: Quite interested, A3: Neither interested nor disinterested, A4: Not very interested, A5: Not interested at all, A6: Don’t know)
 - ST_Q2. Do you actively search for information about science and technology? (A1: Yes, A2: No, A3: Don’t know)
 - ST_Q3: When you have looked for information about science and technology in the past, have you generally been able to find what you were looking for? (A1: Yes, and it tends to be easy to understand; A2: Yes, but it is often difficult to understand; A3: No, I often can’t find what I am looking for; A4: Don’t know)

Respondents’ attitudes are classified into three groups (group with interest, group with potential interest, and group with low interest) by combining the responses to the three questions. For example, if the respondent chooses A1 (Very interested) in the question ST-Q1, A1 (Yes) in ST-Q2, and A2 (Yes, but it is often difficult to understand) in ST-Q3, the respondent is in the group with interest (Table 1).

- (3) Understanding of AI: Three items were prepared to measure the level of understanding of AI. These items were reviewed by AI experts. Two AI experts had varying opinions on the optimal phrasing of the questions and answers. However, when we asked six graduate students studying AI to choose the answers, they

Table 1. Methods of classification into three groups.

	Group with interest	Group with potential interest	Group with low interest
ST_Q1	A1 or A2	A1 or A2 or A3 or A4 or A5	A4 or A5
ST_Q2	A1	A1 or A2	A2
ST_Q3	A1 or A2 or A3	-	-

Note: Respondents who did not meet the above criteria were classified as N/A.

all agreed that option 2 for all items was the correct answer. Therefore, in this study, we considered option 2 for all items as the correct answer.

- Quiz_Q1. Which of the following options is the most appropriate explanation of AI as of today? (1: A robot that thinks and acts on its own without human assistance, 2: A program that makes decisions based on learning results, 3: A computer that interacts with people, 4: A new type of smartphone).
- Quiz_Q2. Which of the following options is the most appropriate explanation of what AI can do as of today? (1: It makes moral decisions on its own, 2: It understands and interprets human languages, 3: It develops software on its own, 4: It has free will).
- Quiz_Q3. Which of the following options is the most appropriate explanation of AI developers as of today? (1: The government is developing AI, 2: Information scientists and researchers are developing AI, 3: Computer programs are developing AI without human intervention, 4: Everyone is developing AI using smartphones).

(4) Items for the scenarios: We first prepared four scenarios, which consisted of short paragraphs of text in Japanese (about 300 words). The scenarios described the use of AI for AI-generated singers (scenario “singer”, see scenario 1 in Appendix B), AI customer service (scenario “service”, see scenario 2 in Appendix B), AI unmanned weapons (scenario “weapon”, see scenario 3 in Appendix B), and AI prediction of criminal activities (scenario “crime”, see scenario 4 in Appendix B). These scenarios involved descriptions of a researcher and included beneficial and anxiety-inducing aspects of AI. In the scenarios, the researcher was facing an ethical dilemma about continuing with research (Figure 1). We asked the respondents to answer the following two questions (Q1, Q2) after reading each scenario.

- Q1. “Do you agree or disagree with this research?” was asked to the respondents. Their responses were rated on a seven-point scale from “I strongly agree with it (= 1)” to “I strongly disagree with it (= 7). Higher scores showed that the respondents disagreed with the scenario.
- Q2. “To what extent should this researcher care about the following category?” was asked to the respondents using the Octagon measurement. Their responses were chosen among a five-point scale (fine with the current situation (= 1), needs to be considered slightly more than now (= 2), needs to be considered moderately more than now (= 3), needs to be considered very much more than now (= 4), needs to be considered extremely more than now (= 5)). Higher scores showed that the respondents had negative attitudes toward the current situation of each scenario.

4.2.2. Statistical descriptions

- (1) We collected 10 variables (Appendices A and C), but only three basic variables (age, gender, and education) were used for analysis. The mean value \pm SEM of age was 46.0 ± 13.5 in men ($n = 519$), and 46.1 ± 13.6 ($n = 510$) in women. The responses for analysis of education were categorized into “below university” (53.4%; elementary school/junior high school, high school, and junior college/vocational school) “university” (44.7%; university (undergraduate), university (graduate)), and “other set of responses” (1.8%; other, I do not know, and I do not want to answer).”
- (2) Interest in S&T: Percentages for the three groups were the group with interest (23.7%), the group with potential interest (43.1%), the group of low interest (22.1%) and N/A (11.2%).
- (3) Understanding of AI: Responses were categorized as “correct” (correctly answered all three quizzes, 49.4%) and “not correct” (50.6%).

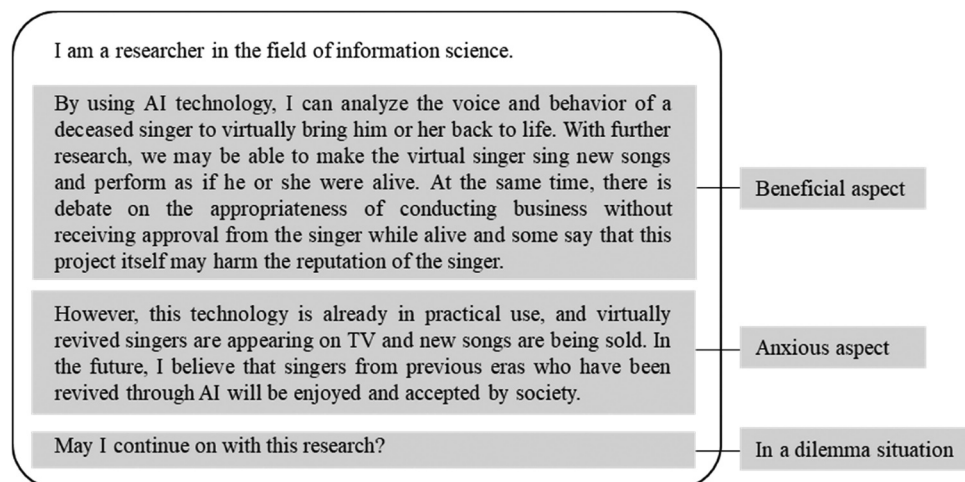


Figure 1. Text of scenario “singer.” The scenario consisted of beneficial and anxious aspects as well as an ethical dilemma.

- (4) Items for scenarios: The mean value \pm SEM of agreement/disagreement with the scenarios (Q1) was 4.88 ± 0.05 in scenario “weapon”, 4.07 ± 0.04 in scenario “singer”, 3.87 ± 0.04 in scenario “crime”, and 3.67 ± 0.04 in scenario “service”. The mean score of the eight themes (Q2) was highest for seven themes (themes 2, 3, 4, 5, 6, 7, 8) in scenario “weapon”, and highest for privacy in scenario “crime” (Table 2). Additionally, the mean score was plotted in the radar chart, which showed that the eight themes were evenly distributed in scenario “singer” and scenario “crime” more than scenario “service” and scenario “weapon” (Figure 2).

4.2.3. Analysis

First, the relationship between the level of agreement/disagreement with each scenario (Q1) and each variable was investigated using a linear logistic regression. Age, gender (“men” served as the baseline), education (“below university” served as the baseline), interest in S&T (“group with high interest” served as the baseline), and understanding of AI (“not correct” served as the baseline) were used as

independent variables. The response to the level of agreement/disagreement to each scenario was used as dependent variable.

Second, the relationship between the response to each theme (Q2) and each variable was investigated using a linear logistic regression. Age, gender (“men” served as the baseline), education (“below university” served as the baseline), interest in S&T (“group with high interest” served as the baseline), and understanding of AI (“not correct” served as the baseline) were used as independent variables. The score of each theme was used as dependent variable. All analyses were conducted using IBM SPSS Statistics 25 software or R version 3.6.3.

5. Results

5.1. Level of agreement/disagreement with the four scenarios

The linear logistic regression showed that the unstandardized coefficient (B) for both gender (women) and interest in S&T (low) were positively significant in all four scenarios (Table 3), suggesting that women more than men and the group with low interest more than the group with high interest disagreed with the scenarios. The unstandardized coefficient (B) of age was positively significant for scenario “service,” “weapon,” “crime,” suggesting that older respondents were more likely to disagree with the three scenarios than young respondents. The unstandardized coefficient (B) for the AI quiz (correct answer) was positively significant only in scenario “weapon.” This suggests that respondents who understand AI disagreed more than the others with the use of AI for unmanned weapons.

Additionally, we conducted one-way analysis of variance (ANOVA) with repeated measures to investigate the effect of scenarios. The effect of scenarios was statistically significant ($F = 227.332$, $df = 3$, $p < .001$), demonstrating that the level of agreement/disagreement differed across scenarios. The post-hoc t -test with Bonferroni correction revealed that the statistical difference was found in all the combination of two scenarios (between scenario “singer” and “service,” $p < .001$; between “singer” and “weapon,” $p < .001$; between “singer” and “crime,”

Table 2. Responses for the eight themes in Q2.

	Scenario “singer”		Scenario “service”		Scenario “weapon”		Scenario “crime”	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
1. Privacy	3.15	0.05	3.34	0.04	3.25	0.05	3.62	0.04
2. Accountability	3.09	0.04	3.13	0.04	3.78	0.04	3.54	0.04
3. Safety and security	3.11	0.04	3.59	0.04	3.97	0.04	3.83	0.04
4. Transparent and explainability	3.09	0.04	3.26	0.04	3.79	0.04	3.62	0.04
5. Fairness and nondiscrimination	3.08	0.04	3.16	0.04	3.75	0.04	3.53	0.04
6. Human control of technology	3.19	0.04	3.19	0.04	3.95	0.04	3.56	0.04
7. Professional responsibility	3.15	0.04	3.14	0.04	3.85	0.04	3.51	0.04
8. Promotion of human value	3.26	0.04	3.10	0.04	3.74	0.04	3.42	0.04

This table shows the mean value and standard error of the mean (SEM). The themes the mean value was highest across the scenarios were shown in bold.

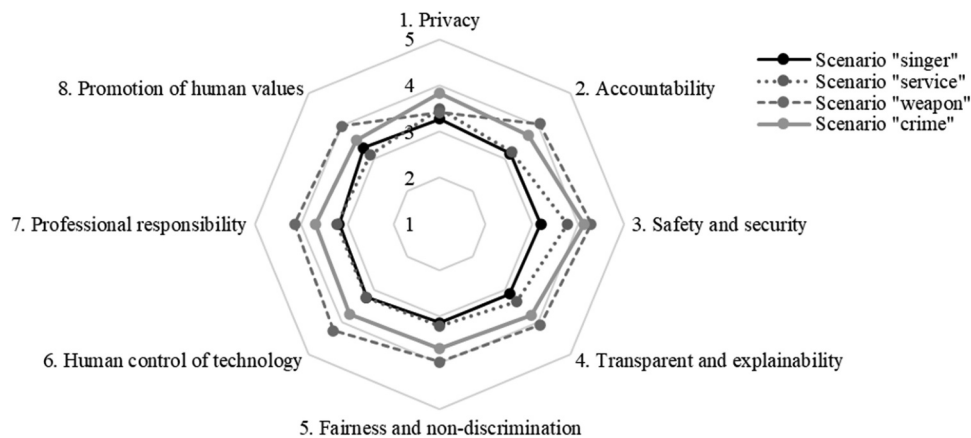


Figure 2. Octagon radar chart for the mean scores. The respondents chose a response on a five-point scale (fine with the current situation (= 1) to needs to be considered extremely more than now (= 5)). The mean scores are shown on four different lines. A higher score shows that the respondent has a negative attitude toward the scenario.

Table 3. Statistical values of the agreement/disagreement analysis of the scenarios.

	Raw means	Scenario "singer"				Scenario "service"				Scenario "weapon"				Scenario "crime"			
		95% confidence interval for (B)				95% confidence interval for (B)				95% confidence interval for (B)				95% confidence interval for (B)			
		B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	46.00 ± 13.56	0.01	0.00	0.01	.112	0.01	0.01	0.02	.000*	0.01	0.01	0.02	.000*	0.01	0.00	0.01	.026*
Gender (women)	0.50	0.22	0.03	0.40	.021*	0.18	0.02	0.33	.024*	0.32	0.12	0.51	.002*	0.20	0.02	0.39	.029*
Education (university: undergraduate and graduate)	0.45	0.05	-0.13	0.23	.574	-0.10	-0.25	0.06	.215	0.07	-0.12	0.27	.464	-0.05	-0.23	0.13	.574
Education (other set of responses)	0.02	0.34	-0.32	0.99	.312	0.57	0.03	1.11	.038*	0.16	-0.54	0.85	.657	0.06	-0.59	0.70	.863
Interest in S&T (low)	0.22	0.30	0.03	0.57	.031*	0.44	0.21	0.66	.000*	0.31	0.03	0.60	.033*	0.29	0.02	0.56	.033*
Interest in S&T (middle)	0.43	0.27	0.04	0.50	.02*	0.13	-0.05	0.32	.165	0.32	0.08	0.56	.008*	0.19	-0.03	0.41	.095
Interest in S&T (NA)	0.11	0.15	-0.17	0.47	.352	0.39	0.12	0.65	.004*	-0.03	-0.37	0.30	.842	0.28	-0.04	0.59	.084
AI quiz (correct answer)	0.49	0.05	-0.12	0.22	.571	-0.10	-0.24	0.05	.194	0.59	0.40	0.77	.000*	0.02	-0.15	0.19	.823
Observations		1029				1029				1029				1029			
R2		0.02				0.06				0.08				0.02			

The column of raw means presents means of age and rate of gender, education, interest in S&T, and AI quiz. The column of scenarios presents the unstandardized partial regression coefficient (B), 95% confidence interval for (B) and *p*-value (*p*). Results from linear logistic regression analysis. Significance at the five-percent level is indicated by *.

p = .006; between "service" and "weapon," *p* < .001; between "service" and "crime," *p* = .004; between "weapon" and "crime," *p* < .001). This suggests that the respondents were likely to disagree to scenario "weapon" more than other scenarios.

5.2. Relationship between the variables and the responses to the eight themes

Scenario "singer": The unstandardized coefficient (B) of age and gender (women) was significantly positive for all themes (Table 4), suggesting that older respondents and women showed negative attitudes toward these themes in this scenario. The unstandardized coefficient (B) of interest in S&T (low) was negatively significant in seven themes except for "privacy," suggesting that group with low interest more than the group with high interest in S&T considered these seven themes are likely to be fine in this scenario.

Scenario "service": The unstandardized coefficient (B) of age was positively significant for the all themes (Table 5), suggesting that older respondents showed negative attitudes toward these themes in this scenario. The unstandardized coefficient (B) of gender (women) was positively significant in seven themes except for "human control of technology," meaning that women more than men showed negative attitudes toward these themes. The unstandardized coefficient (B) of interest in S&T (low) was negatively significant in the six themes except for "promotion of human value" and "human control of technology." This suggests that the low interest group in S&T more than the high interest group considered that these six themes are likely to be fine in this scenario. Finally, the unstandardized coefficient (B) of the AI quiz (correct answer) was positively significant only in two themes of "privacy" and "safety and security," suggesting that those who understand AI considered that these two themes should be considered more in this scenario.

Scenario "weapon": The unstandardized coefficient (B) of age, gender (women) and AI quiz (correct answer) were all positively significant for all themes (Table 6), suggesting that older more than young respondents, women more than men, and those who understand AI considered that all the themes

should be considered more in this scenario. The unstandardized coefficient (B) of S&T (low) was negatively significant for all themes, showing that the group with low interest in S&T more than the group with high interest was likely to consider that all these themes were fine in this scenario.

Scenario ("crime"): The unstandardized coefficient (B) of age and gender was positively significant for all themes (Table 7), suggesting that older more than younger respondents considered these themes should be considered more in this scenario. The unstandardized coefficient (B) of interest in S&T (low) was negatively significant in six themes except for "privacy" and "human control of technology," meaning that the group with low interest in S&T more than the group with high interest in S&T was likely to consider that these six themes were fine in this scenario. Finally, the unstandardized coefficient (B) of the AI quiz was positively significant for all themes, suggesting that those who understand AI showed negative attitudes toward these themes.

5.3. Answers to research questions

- RQ1: Respondents showed significant disagreement with using AI for unmanned weapons, scenario "weapon", and they showed significantly higher levels of anxiety for this scenario (Table 2) more than the other scenarios.
- RQ2: Age was likely to be related to attitudes toward AI ethics across all the themes and scenarios, but gender, interest in S&T and understanding of AI differently related depending on the themes and scenarios (Tables 4–7).

6. Discussion

We investigated public attitudes toward AI ethics using the Octagon measurement focusing on the eight themes in four different scenarios. It was shown that people in Asia-Pacific countries including Japan think that AI has a positive effect

Table 4. Statistical values of the responses to the eight themes in scenario “singer”

	1. Privacy				2. Accountability				3. Safety and security				4. Transparency and explainability			
	95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)			
	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	0.01	0.00	0.02	0.010*	0.01	0.00	0.02	0.001*	0.01	0.01	0.02	0.000*	0.01	0.01	0.02	0.000*
Gender (women)	0.47	0.28	0.66	0.000*	0.32	0.14	0.50	0.001*	0.35	0.17	0.54	0.000*	0.27	0.09	0.45	0.003*
Education (university; undergraduate and graduate)	-0.05	-0.24	0.13	0.579	-0.07	-0.24	0.11	0.474	-0.13	-0.31	0.05	0.164	-0.06	-0.24	0.11	0.479
Education (other set of responses)	-0.04	-0.71	0.63	0.917	-0.30	-0.94	0.34	0.362	-0.10	-0.75	0.55	0.762	-0.26	-0.89	0.37	0.424
Interest in S&T (low)	-0.27	-0.55	0.01	0.056	-0.30	-0.57	0.04	0.026*	-0.41	-0.68	-0.14	0.003*	-0.33	-0.59	-0.07	0.013*
Interest in S&T (middle)	0.01	-0.22	0.24	0.944	-0.04	-0.27	0.18	0.693	-0.01	-0.24	0.22	0.921	0.00	-0.22	0.22	0.988
Interest in S&T (NA)	-0.46	-0.78	-0.13	0.006*	-0.43	-0.75	-0.12	0.006*	-0.41	-0.73	-0.09	0.011*	-0.49	-0.80	-0.18	0.002*
AI quiz (correct answer)	0.19	0.01	0.37	0.037*	0.06	-0.11	0.24	0.458	0.08	-0.09	0.26	0.363	0.04	-0.13	0.21	0.660
Observations		1029				1029				1029				1029		
R2		0.05				0.04				0.06				0.05		
	5. Fairness and non-discrimination				6. Promotion of human values				7. Professional responsibility				8. Human control of technology			
	95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)			
	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	0.02	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.01	0.01	0.02	0.000*
Gender (women)	0.23	0.05	0.42	0.012*	0.34	0.16	0.52	0.000*	0.30	0.12	0.48	0.001*	0.32	0.13	0.51	0.001*
Education (university; undergraduate and graduate)	-0.08	-0.26	0.10	0.367	-0.04	-0.22	0.14	0.670	-0.04	-0.22	0.14	0.639	0.00	-0.19	0.18	0.977
Education (other set of responses)	-0.10	-0.74	0.53	0.750	-0.16	-0.81	0.48	0.616	-0.32	-0.96	0.32	0.325	-0.55	-1.20	0.11	0.102
Interest in S&T (low)	-0.37	-0.63	-0.10	0.007*	-0.39	-0.66	-0.12	0.004*	-0.41	-0.68	-0.15	0.002*	-0.37	-0.64	-0.10	0.007*
Interest in S&T (middle)	-0.03	-0.25	0.20	0.812	-0.06	-0.29	0.16	0.583	-0.03	-0.25	0.19	0.811	0.11	-0.12	0.33	0.360
Interest in S&T (NA)	-0.43	-0.74	-0.12	0.007*	-0.52	-0.83	-0.20	0.001*	-0.47	-0.78	-0.15	0.003*	-0.36	-0.68	-0.04	0.029*
AI quiz (correct answer)	0.05	-0.12	0.22	0.591	0.03	-0.14	0.20	0.730	-0.04	-0.21	0.13	0.676	0.03	-0.14	0.21	0.726
Observations		1029				1029				1029				1029		
R2		0.05				0.06				0.05				0.05		

Note: The column of scenarios presents the unstandardized partial regression coefficient (B), 95% confidence interval for (B) and p-value (p). Results from linear logistic regression analysis. Significance at the five-percent level is indicated by *.

Table 5. Statistical values of the responses to the eight themes in scenario "service"

	1. Privacy				2. Accountability				3. Safety and security				4. Transparency and explainability			
	95% Confidence Interval for (B)		ρ		95% Confidence Interval for (B)		ρ		95% Confidence Interval for (B)		ρ		95% Confidence Interval for (B)		ρ	
	B	Lower	Upper	B	Lower	Upper	B	Lower	Upper	B	Lower	Upper	B	Lower	Upper	ρ
Age	0.01	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.01	0.01	0.02	0.000*	0.01	0.01	0.02	0.000*
Gender (women)	0.39	0.21	0.57	0.000*	0.22	0.05	0.39	0.013*	0.36	0.19	0.53	0.000*	0.19	0.02	0.36	0.03**
Education (university: undergraduate and graduate)	0.14	-0.04	0.32	0.128	0.04	-0.13	0.21	0.614	0.05	-0.12	0.21	0.596	0.06	-0.11	0.23	0.497
Education (other set of responses)	0.00	-0.64	0.64	0.997	-0.11	-0.72	0.49	0.711	-0.06	-0.66	0.55	0.853	-0.31	-0.91	0.28	0.304
Interest in S&T (low)	-0.28	-0.55	-0.02	0.037*	-0.33	-0.59	-0.08	0.01*	-0.40	-0.65	-0.15	0.002*	-0.36	-0.61	-0.11	0.005*
Interest in S&T (middle)	-0.06	-0.28	0.16	0.610	-0.10	-0.32	0.11	0.332	-0.13	-0.34	0.08	0.214	-0.12	-0.33	0.09	0.270
Interest in S&T (NA)	-0.63	-0.94	-0.32	0.000*	-0.48	-0.78	-0.19	0.001*	-0.57	-0.86	-0.27	0.000*	-0.48	-0.77	-0.18	0.001*
AI quiz (correct answer)	0.21	0.04	0.38	0.015*	0.09	-0.08	0.25	0.297	0.26	0.10	0.42	0.002*	0.13	-0.03	0.29	0.119
Observations			1029			1029					1029				1029	
R2			0.06			0.06					0.06				0.05	

[illegible]

Note: The column of raw means presents means of age and rate of gender, education, interest in S&T, and AI quiz. The column of scenarios presents the unstandardized partial regression coefficient (B), 95% confidence interval for (B) and p-value (p). Results from linear logistic regression analysis. Significance at the five-percent level is indicated by *.

Table 6. Statistical values of the responses to the eight themes in scenario “weapon”

	1. Privacy				2. Accountability				3. Safety and security				4. Transparency and explainability			
	95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)			
	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	0.03	0.02	0.03	0.000*	0.02	0.01	0.02	0.000*	0.01	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*
Gender (women)	0.29	0.09	0.48	0.004*	0.30	0.12	0.47	0.001*	0.26	0.09	0.43	0.003*	0.26	0.09	0.43	0.003*
Education (university: undergraduate and graduate)	-0.08	-0.27	0.11	0.403	0.08	-0.09	0.25	0.371	0.04	-0.13	0.20	0.671	0.00	-0.16	0.17	0.954
Education (other set of responses)	0.07	-0.61	0.76	0.832	-0.33	-0.93	0.28	0.289	-0.27	-0.87	0.32	0.369	-0.31	-0.91	0.28	0.306
Interest in S&T (low)	-0.34	-0.63	-0.06	0.019*	-0.43	-0.68	-0.18	0.001*	-0.42	-0.66	-0.17	0.001*	-0.33	-0.58	-0.08	0.009*
Interest in S&T (middle)	0.07	-0.17	0.31	0.568	-0.01	-0.22	0.20	0.954	-0.04	-0.25	0.17	0.711	0.04	-0.17	0.25	0.706
Interest in S&T (NA)	-0.26	-0.60	0.08	0.129	-0.58	-0.87	-0.28	0.000*	-0.62	-0.91	-0.32	0.000*	-0.53	-0.82	-0.24	0.000*
AI quiz (correct answer)	0.23	0.04	0.41	0.016*	0.46	0.30	0.62	0.000*	0.53	0.37	0.69	0.000*	0.48	0.33	0.64	0.000*
Observations																
R2																
		1029				1029				1029				1029		
		0.08				0.11				0.10				0.11		
	5. Fairness and non-discrimination				6. Promotion of human values				7. Professional responsibility				8. Human control of technology			
	95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)				95% Confidence Interval for (B)			
	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	0.02	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.02	0.01	0.03	0.000*
Gender (women)	0.23	0.06	0.41	0.009*	0.26	0.09	0.42	0.003*	0.31	0.14	0.48	0.000*	0.28	0.10	0.46	0.002*
Education (university: undergraduate and graduate)	-0.04	-0.21	0.13	0.647	0.06	-0.10	0.23	0.466	0.06	-0.11	0.23	0.470	-0.05	-0.22	0.13	0.588
Education (other set of responses)	-0.20	-0.81	0.42	0.530	-0.31	-0.90	0.27	0.295	-0.38	-0.99	0.22	0.212	-0.53	-1.16	0.09	0.094
Interest in S&T (low)	-0.46	-0.72	-0.21	0.000*	-0.42	-0.67	-0.18	0.001*	-0.44	-0.69	-0.19	0.001*	-0.35	-0.60	-0.09	0.009*
Interest in S&T (middle)	0.00	-0.21	0.21	0.989	0.02	-0.19	0.22	0.857	-0.01	-0.22	0.20	0.947	0.10	-0.11	0.32	0.345
Interest in S&T (NA)	-0.64	-0.94	-0.34	0.000*	-0.64	-0.93	-0.36	0.000*	-0.67	-0.97	-0.38	0.000*	-0.40	-0.71	-0.10	0.01*
AI quiz (correct answer)	0.36	0.19	0.52	0.000*	0.49	0.33	0.65	0.000*	0.45	0.29	0.61	0.000*	0.41	0.25	0.58	0.000*
Observations																
R2																
		1029				1029				1029				1029		
		0.10				0.12				0.11				0.11		

Note: The column of raw means presents means of age and rate of gender, education, interest in S&T, and AI quiz. The column of scenarios presents the unstandardized partial regression coefficient (B), 95% confidence interval for (B) and p-value (p). Results from linear logistic regression analysis. Significance at the five-percent level is indicated by *.

Table 7. Statistical values of the responses to the eight themes in scenario "crime"

	1. Privacy				2. Accountability				3. Safety and security				4. Transparency and explainability			
	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	0.01	0.00	0.02	0.001*	0.01	0.00	0.02	0.004*	0.01	0.00	0.01	0.009*	0.01	0.00	0.02	0.000*
Gender (women)	0.29	0.11	0.47	0.002*	0.18	0.00	0.35	0.046*	0.21	0.04	0.39	0.015*	0.23	0.05	0.40	0.01*
Education (university: undergraduate and graduate)	0.02	-0.16	0.19	0.854	-0.11	-0.28	0.06	0.202	-0.09	-0.26	0.08	0.297	-0.06	-0.23	0.11	0.469
Education (other set of responses)	-0.01	-0.64	0.63	0.986	-0.28	-0.90	0.33	0.367	-0.18	-0.78	0.43	0.564	-0.38	-0.99	0.23	0.220
Interest in S&T (low)	-0.25	-0.51	0.02	0.065	-0.33	-0.58	0.07	0.012*	-0.33	-0.58	-0.08	0.011*	-0.36	-0.62	-0.11	0.005*
Interest in S&T (middle)	-0.04	-0.26	0.18	0.730	-0.03	-0.25	0.18	0.769	-0.09	-0.30	0.12	0.410	-0.04	-0.25	0.17	0.695
Interest in S&T (NA)	-0.54	-0.86	-0.23	0.001*	-0.46	-0.76	-0.23	0.003*	-0.47	-0.77	-0.17	0.002*	-0.45	-0.75	-0.15	0.003*
AI quiz (correct answer)	0.38	0.21	0.55	0.000*	0.27	0.11	0.44	0.001*	0.52	0.36	0.68	0.000*	0.28	0.12	0.44	0.001*
Observations		1029				1029					1029					
R2		0.06				0.05					0.07				0.06	

	5. Fairness and non-discrimination				6. Promotion of human values				7. Professional responsibility				8. Human control of technology			
	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p	B	Lower	Upper	p
Age	0.01	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.02	0.01	0.02	0.000*	0.02	0.01	0.03	0.000*
Gender (women)	0.19	0.01	0.37	0.039*	0.25	0.08	0.43	0.005*	0.34	0.16	0.52	0.000*	0.24	0.06	0.42	0.010*
Education (university: undergraduate and graduate)	-0.13	-0.31	0.04	0.143	-0.11	-0.28	0.07	0.230	-0.10	-0.28	0.07	0.241	-0.10	-0.27	0.08	0.282
Education (other set of responses)	-0.25	-0.87	0.38	0.439	-0.17	-0.79	0.38	0.46	0.602	-0.90	0.34	0.373	-0.43	-1.06	0.20	0.185
Interest in S&T (low)	-0.41	-0.67	0.15	0.002*	-0.30	-0.56	-0.04	0.024*	-0.36	-0.61	-0.10	0.006*	-0.15	-0.41	0.11	0.257
Interest in S&T (middle)	-0.01	-0.23	0.21	0.917	-0.05	-0.27	0.17	0.643	-0.10	-0.31	0.12	0.382	-0.12	-0.10	0.34	0.300
Interest in S&T (NA)	-0.47	-0.78	-0.17	0.003*	-0.35	-0.65	-0.17	0.025*	-0.40	-0.70	-0.10	0.009*	-0.18	-0.48	0.13	0.265
AI quiz (correct answer)	0.24	0.07	0.40	0.006*	0.31	0.14	0.48	0.000*	0.28	0.12	0.45	0.001*	0.21	0.04	0.38	0.014*
Observations		1029				1029				1029				1029		
R ²		0.06				0.07				0.07				0.07		

Note: The column of raw means presents means of age and rate of gender, education, interest in S&T, and AI quiz. The column of scenarios presents the unstandardized partial regression coefficient (B), 95% confidence interval for (B) and p-value (p). Results from linear logistic regression analysis. Significance at the five-percent level is indicated by *.

on society (Funk et al., 2020). Our finding emphasized that the respondents expressed varying levels of concern regarding AI ethics across scenarios.

Older respondents tended to answer that all themes for AI ethics need to be considered more than young respondents across the scenarios. This result was supported by a global survey in many countries that older adults are more likely to disagree with the idea that the development of AI for a society was a good thing (Funk et al., 2020). Our results emphasize that this tendency is likely to be found in AI ethics across scenarios. However, it remains unclear whether people's attitudes toward AI ethics will change from positive to negative as they grow older, or if this is due to a generation gap. A generation that is surrounded by AI from a young age may not feel the need to reject AI even when they get older. On the other hand, gender on AI ethics was positive, but theme-dependent more than age. This confirms previous findings that women are more negative toward AI than men (e.g., Funk et al., 2020). We also found that the AI quiz was more scenario- and theme-dependent (e.g., "privacy"). The attitudes toward AI ethics are clearly divided by the level of knowledge of AI. People with a higher level of knowledge of AI tend to show more cautious attitudes toward AI ethics especially for scenario "weapon" and scenario "crime," and people with a lower level of knowledge of AI affirm the current situation and tend to have less cautious attitudes. This indicates that those with a higher level of knowledge of AI are likely to express that AI ethics in those two scenarios should be considered.

Note that, among the four scenarios, the respondents disagreed and were highly anxious about AI ethics in scenario "weapon." The use of AI in war has also been a major concern of experts (Anderson et al., 2018). Since this scenario is directly related to human life, this result is convincing as it is a remarkable result as the level is different from the other three. Ethically Aligned Design (EAD) Version 1 from the IEEE (IEEE, 2016), clearly mention autonomous weapon systems. However, Japanese AI guidelines tend to focus on the researcher's ethics, usually from the short-term and realistic view, and do not mention autonomous weapons (Ema, 2017). Japan has a constitution that promises not to go to war and has not had a war more than 76 years. 85.5% Japanese respondents answered that there is a risk that Japan will be launched or involved in a war (Cabinet Office, 2018), suggesting their concerns about war. However, in scenario "weapon," it is unclear whether the respondents disagreed with weapon or the AI involvement in the weapon. This finding suggests that we would likely have obtained different results if we had conducted this survey in other countries than Japan. At the same time, it is useful for comparing the difference in awareness between the public and professionals, and the difference among countries.

From the perspective of science and technology studies, the concept of Responsible Research Innovation (RRI) is important for society. RRI emphasizes that diverse citizens and scientists learn from each other and create social systems together (e.g., Von Schomberg, 2012, 2013). It is

necessary to create a situation in which diverse people can easily participate in the discussion. A certain amount of scientific knowledge will make discussions more efficient, not through the often-criticized "deficit model" (where scientists and governments try to encourage public acceptance of science by imparting scientific knowledge, for example, Simis et al., 2016; Trench, 2008), but more importantly through easy access to scientific information on the internet and social network services.

This study has limitations. First, our AI quiz is not a perfect way to measure an understanding of AI, as understandings of AI vary. We considered that our AI quiz was much more objective than asking the question "Do you know about AI?" However, we need to redevelop the quiz to measure the level of understanding of AI with the help of advice from experts.

The second limitation was the respondents' comprehension level of the eight themes. In this study, we could not check whether the respondents fully understand the meaning of the eight themes. That may be the reason why in each scenario the radar chart (Figure 2) tended to be even and was distributed in concentric circles. Adding some explanations or including items to check if the participants correctly understood the theme could make the results more accurate.

The last limitation is a methodological issue. We used an online survey to collect responses. But the entire population does not have access to the Internet in Japan (the percentage of Internet use was 79.8% in 2019, Ministry of Internal Affairs and Communications, 2019a), and our target was limited to people 20–69 years old. We need to be aware that the results did not include the attitudes of the entire public in Japan.

Considering AI ethics is essential in designing AI for engineers and researchers. They should first be aware of AI ethics focusing on the eight themes not only to understand their own attitudes toward AI ethics but also to understand public concerns about AI ethics. This enables an enhanced dialogue with various stakeholders about AI. We cannot provide a general strategy of AI ethics, as the public responses to AI ethics will be different across scenarios. Engineers and researchers could use Octagon measurement for each scenario to design their new AI technology both for themselves and society.

In conclusion, we found that public responses to the use of AI ethics varied depending on scenarios (the context). People showed strong disagreement and were anxious about many themes in the scenario for AI unmanned weapons. Age was significantly related to all themes of AI ethics across scenarios, but other variables related depending on the themes of the AI ethics and the scenarios. We targeted the public in this study. If we had targeted AI experts, they might have revealed different attitudes toward the eight themes than the public. We considered that our Octagon measurement may be useful to understand how people feel about the risks of rapidly permeating technologies and what the problems are, although more specific explanations of the eight themes are required to add in the questionnaire for the participants. Future study is required to investigate whether we will get

different results if we conduct this survey with another population or in another country, and our Octagon measurement can be applied to other science and technology topics.

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Appendix A. Sample composition of age, gender and location

Variables		Total population (October 1, 2019)		N in this study	
		N	%	Target	Collected
Age	20's	12628000	0.16	167	160
	30's	14303000	0.18	189	186
	40's	18520000	0.24	244	249
	50's	16278000	0.21	215	223
	60's	16232000	0.21	214	211
Gender	Men	39255000	0.50	518	519
	Women	38708000	0.50	511	510
Location	Hokkaido	3212000	0.04	42	41
	Aomori-ken	750001	0.01	10	8
	Iwate-ken	730002	0.01	10	10
	Miyagi-ken	1450003	0.02	19	24
	Akita-ken	563004	0.01	7	12
	Yamagata-ken	636005	0.01	8	5
	Fukushima-ken	1120006	0.01	15	11
	Ibaraki-ken	1759007	0.02	23	25
	Tochigi-ken	1204008	0.02	16	11
	Gumma-ken	1177009	0.02	16	18
	Saitama-ken	4654010	0.06	61	63
	Chiba-ken	3915011	0.05	52	44
	Tokyo-to	9346012	0.12	123	122
	Kanagawa-ken	5903013	0.08	78	85
	Niigata-ken	1327014	0.02	18	17
	Toyama-ken	615015	0.01	8	11
	Ishikawa-ken	684016	0.01	9	10
	Fukui-ken	454017	0.01	6	5
	Yamanashi-ken	487018	0.01	6	6
	Nagano-ken	1195019	0.02	16	14
	Gifu-ken	1184020	0.02	16	12
	Shizuoka-ken	2200021	0.03	29	30
	Aichi-ken	4750022	0.06	63	66
	Mie-ken	1073023	0.01	14	15
	Shiga-ken	870024	0.01	11	6
	Kyoto-fu	1582025	0.02	21	19
	Osaka-fu	5478026	0.07	72	73
	Hyogo-ken	3315027	0.04	44	49
	Nara-ken	787028	0.01	10	12
	Wakayama-ken	541029	0.01	7	6
	Tottori-ken	326030	0.00	4	2
	Shimane-ken	382031	0.00	5	7
	Okayama-ken	1117032	0.01	15	13
	Hiroshima-ken	1683033	0.02	22	26
	Yamaguchi-ken	782034	0.01	10	10
	Tokushima-ken	429035	0.01	6	5
	Kagawa-ken	561036	0.01	7	9
	Ehime-ken	783037	0.01	10	9
	Kochi-ken	400038	0.01	5	5
	Fukuoka-ken	3135039	0.04	41	50
	Saga-ken	482040	0.01	6	2
	Nagasaki-ken	775041	0.01	10	12
	Kumamoto-ken	1024042	0.01	14	11
	Oita-ken	660043	0.01	9	8
	Miyazaki-ken	621044	0.01	8	7
	Kagoshima-ken	937045	0.01	12	12
	Okinawa-ken	902046	0.01	12	11

The samples matched the current demographic profile of the Japanese population by age, gender, and location. Total population in Japan was the data published on 1 October 2019 (Ministry of Internal Affairs and Communications, 2019b). "Target" means the number we targeted to collect. "Collected" means the number we actually collected.

Appendix B. Questionnaire sheet in English and Japanese

=== English version ===

1. How old are you?
[() years old]

2. What is your gender?
[Male/Female]

3. What is the last school from which you graduated? If you are still in school, please assume that you have graduated from that school while answering. Dropping out is counted as graduated.
[Elementary school, Junior high school/High school/Junior college/Vocational school/University (undergraduate)/University (graduate)/Other/I do not know/I do not want to answer]

4. How much are you interested in science and technology? Please select only one.
[Very interested/ Quite interested/ Neither interested not disinterested/ Not very interested/ Not interested at all/ Don't know]

5. Do you actively search for information about science and technology?
[Yes/ No/ Don't know]

6. When you have looked for information about science and technology in the past, have you generally been able to find what you were looking for? Please select the closest answer?
[Yes, and it tends to be easy to understand/ Yes, but it is often difficult to understand/No, I often can't find what I am looking for/ Don't know]

7. Currently, which political party do you support the most? Please tell us the political party.
[Liberal Democratic Party (自民党)/ The Constitutional Democratic Party of Japan (立憲民主党)/ Democratic Party For the People (国民民主党)/ Komeito (公明党)/ Japanese Communist Party (日本共産党)/ Nippon Ishin (日本維新の会)/ Social Democratic Party (社民党)/ The Party to Protect the People from NHK (NHKから国民を守る党)/ Reiwa Shinsengumi (れいわ新選組)]

8. Approximately how long do you use a computer or smartphone per day?
[Less than 30 minutes/ 30 minutes to 1 hour/ 1 hour to 2 hours/ 2 hours to 3 hours/ 3 hours to 4 hours/ 4 hours to 6 hours/ 6 hours to 8 hours/ 8 hours to 10 hours/ 10 hours or more/ I do not use them at all]

*The items 9–11 were randomly presented to the respondents (This sentence was not shown to the respondents.)

9. Which of the following options is the most appropriate explanation of AI as of today?
[A robot that thinks and acts on its own, without human assistance/ A program that makes decisions based on learning results/ A computer that interacts with people/ A new type of smartphone]

10. Which of the following options is the most appropriate explanation of what AI can do as of today?
[It makes moral decisions on its own/ It understands and interprets human languages/ It develops software on its own/ It has free will]

11. Which of the following options is the most appropriate explanation of AI developers as of today?
[The government is developing AI/ Information scientists and researchers are developing AI/ Computer programs are developing AI without human intervention/ Everyone is developing AI using smartphones]

*The four scenarios below were randomly presented to the respondents (This sentence was not shown to the respondents).

Please read the following script and answer the question that follows.

Scenario 1

I am a researcher in the field of information science. By using AI technology, I can analyze the voice and behavior of a deceased singer to virtually bring him or her back to life. With further research, we may be able to make the virtual singer sing new songs and perform as if he or she were alive. At the same time, there is debate on the appropriateness of conducting business without receiving approval from the singer while alive and some say that this project itself may harm the reputation of the singer. However, this technology is already in practical use, and virtually revived singers are appearing on TV and new songs are being sold. In the future, I believe that singers from previous eras who have been revived through AI will be enjoyed and accepted by society. May I continue on with this research?

12. Do you agree or disagree with this research?
[1: I strongly agree with it – 7: I strongly disagree with it]

13. To what extent should this researcher care about the following category? Please check/select the box closest to your opinion.

	1 Fine with the current situation	2 Needs to be considered slightly more than now	3 Needs to be considered moderately more than now	4 needs to be considered very much more than now	5 needs to be considered extremely more than now
Privacy					
Accountability					
Safety and Security					
Transparency and Explainability					
Fairness and non-discrimination					
Human Control of Technology					
Professional Responsibility					
Promotion of Human Values					

Scenario 2

I am a researcher in the field of information science. By using AI technology, I can analyze data such as customer's purchase histories and keyword searches to predict that person's preferences. With further research, customers may be able to find products that they like by simply accessing a website. Meanwhile, some question the appropriateness of companies guiding the behavior and preferences of customers without their knowledge based on the company's intent.

However, many companies are already adopting this technology. In the future, I believe AI marketing will be further accepted by society and that it will become a methodology that will strongly support economic activities. May I continue on with this research?

14. Do you agree or disagree with this research?
[1: I strongly agree with it – 7: I strongly disagree with it]

15. To what extent should this researcher care about the following category? Please check/select the box closest to your opinion.

*The matrix options are same as the first scenarios, and we omitted it here.

Scenario 3

I am a researcher in the field of information science.

By using AI technology, we can create various unmanned weapons that can act autonomously. With further research, we can remove human combatants from dangerous operations and reduce human casualties; we may even be able to attack with greater deadly force than with human combatants. At the

same time, there is the ethical question of AI killing people and also discussions regarding the legal liabilities in the event of a malfunction. However, many unmanned weapons are already being deployed in actual battlefields. In the future, I believe the usefulness of unmanned weapons will be accepted by society and that their performance will serve national interests.

May I continue on with this research?

16. Do you agree or disagree with this research?

[1: I strongly agree with it – 7: I strongly disagree with it]

17. To what extent should this researcher care about the following category? Please check/select the box closest to your opinion.

*The matrix options are same as the first scenarios, and we omitted it here.

Scenario 4

I am a researcher in the field of information science. By using AI technology, if we analyze history of peoples' activities through their stored history in databases of personal credit cards, security cameras, etc., we may be able to predict possible criminal activities such as theft and murder at a higher precision. With further research, we can prevent various crimes from occurring, and limit the activities of people that are more likely to commit a crime. Meanwhile, the appropriateness of using personal information for monitoring people and limiting the rights of people based on predictions is under debate. However, information such as the activity history of an individual is already being analyzed by AI and used in marketing. In the future, I believe people will accept AI technology that goes further into personal privacy and that it will be of great benefit for protecting the safety and security of society. May I continue on with this research?

18. Do you agree or disagree with this research?

[1: I strongly agree with it – 7: I strongly disagree with it]

19. To what extent should this researcher care about the following category? Please check/select the box closest to your opinion.

*The matrix options are same as the first scenarios, and we omitted it here.

=== Japanese version (original) ===

1. あなたの年齢をお答えください。

[() 歳]

2. あなたの性別をお答えください。

[男性/ 女性]

3. あなたが最後に卒業された学校はどちらですか。在学の方は卒業とみなしてお答えください。中退も卒業とみなしてください。

[小学校■中学校 (及び旧制小学校)/高校 (及び旧制中学校)/短大■専門学校/ 大学 (及び旧制高校)/大学院/ その他/ わからない/ 答えたくない]

4. 科学■技術に関心がありますか?以下の選択肢の中から最も近いものを1つだけお答え下さい。

[とても関心がある/ 関心がある/ 関心があるともないとも言えない/ 関心がない/ 全く関心がない/わからない]

5. 科学■技術に関する情報を積極的に調べることはありますか?

[はい/ いいえ/わからない]

6. 過去、科学■技術に関する情報を調べた際に、探している情報を見つけることができましたか?以下の選択肢の中から最も近いものを1つだけお答えください。

[見つけられた。大抵、その内容は容易に理解できる。/ 見つけられた。しかし、ほとんどの場合、この内容を理解することは難しい/ 見つけられなかった。ほとんどの場合、探している情報は見つけられない。/ わからない]

7. あなたは今、どの政党をもっとも支持していますか。政党名でお答えください。

[自民党/ 立憲民主党/ 国民民主党/ 公明党/ 共産党/ 日本維新の会/ 社民党/ NHKから国民を守る党/ れいわ新選組/ その他の政党/ 支持する政党はない/ 分からない/ 答えたくない]

8. あなたは、1日あたりどの程度、パソコンまたはスマートフォンを使っていますか?

[30分未満/ 30分以上~1時間未満/ 1時間以上~2時間未満/ 2時間以上~3時間未満/ 3時間以上~4時間未満/ 4時間以上~6時間未満/ 6時間以上~8時間未満/ 8時間以上~10時間未満/ 10時間以上/ 全く使用していない]

※The items 9–11 were randomly presented to the respondents. (This sentence was not shown to the respondents.)

9. 現時点で存在する人工知能 (AI) の説明としてもっとも適切な選択肢はどれでしょうか?

[人間の助けなしに自分で考えて行動するロボット/ 学習結果に基づいて判断を下すプログラム/ 人間とやりとりするコンピュータ/ 新しいタイプのスマートフォン]

10. 現時点で存在する人工知能 (AI) にできることの説明としてもっとも適切な選択肢はどれでしょうか?

[道徳的な判断を自分で下す/ 人間の言葉を理解し、解釈する/ 自らソフトウェアを開発する/ 自由意志を持つ]

11. 現在、人工知能 (AI) の開発者の説明としてもっとも適切な選択肢はどれでしょうか?

[政府がAIを開発している/ 情報科学者や研究者がAIを開発している/ 人間の関与なしにコンピュータプログラムが自身で開発している/ 誰もがスマートフォンを使って開発している]

※The four scenarios below were randomly presented to the respondents. (This sentence was not shown to the respondents.)

以下のシナリオを読み、続く質問にお答えください。

シナリオ1

私は情報科学分野の研究者です。AIの技術を使えば、亡くなった歌手の歌声や立ち振る舞いを分析して、バーチャルに甦らせることができます。この研究が進めば、あたかもその歌手が生きているかのように新曲を歌わせ、パフォーマンスをさせることができるかもしれません。その一方で生前の歌手に許可を得ずにビジネスを行うことの是非や、そもそもこのような取り組み自体がその歌手の尊厳を傷つけるのではないかという議論もあります。もともと、すでにこの技術は実用化されており、バーチャルに甦った歌手がテレビに登場したりその新曲が発売されたりしています。私は将来、AIによって過去の歌手が再び活躍を始めることは社会に受け入れられ、

	2今より やや配慮 が必要で ある	3今より かなり配 慮が必要 である	4今より 非常に配 慮が必要 である	5今より 極めて配 慮が必要 である
個人のプライバシー	1現状でよい			
説明責任				
安全性とセキュリティ				
ディ(第三者からの侵害)				
透明性と説明可能性				
公平性と無差別				
人間による制御				
専門家の責任				
人間の価値の促進				

人々を楽しませることにつながると考えています。私はこの研究を進めても良いのでしょうか？

12. あなたはこの研究について、賛成ですか、それとも反対ですか？
[1:とても賛成~7:とても反対]

13. この研究者は次に挙げる項目について、どの程度の配慮をする必要があると考えますか。あなたの考えにもっとも近いものに、チェックを入れてください。

シナリオ2

私は情報科学分野の研究者です。AIの技術を使えば、顧客の購買履歴や検索キーワードなどのデータを分析して、その嗜好を予測することができます。この研究が進めば、顧客はウェブサイトにアクセスしただけで自分好みの商品に出会うことができるかもしれません。その一方で、企業の思惑に基づいて顧客の行動や嗜好が知らず知らずのうちに誘導されることの是非も問われています。もともと、すでにこの技術は多くの企業によって採用されています。私は将来、AIによるマーケティングはより広く社会に受け入れられ、経済活動を強力にサポートする方法論になると考えています。私はこの研究を進めても良いのでしょうか？

14. あなたはこの研究について、賛成ですか、それとも反対ですか？
[1:とても賛成~7:とても反対]

15. この研究者は次に挙げる項目について、どの程度の配慮をする必要があると考えますか。あなたの考えにもっとも近いものに、チェックを入れてください。

*The matrix options are same as the first scenarios, and we omitted it here.

シナリオ3

私は情報科学分野の研究者です。AIの技術を使えば、自律的に行動できるさまざまな無人攻撃兵器を作ることができます。この研究が進めば、人間の戦闘員を危険な任務から外すことで人的被害を減らすことや、人間の戦闘員よりも高い殺傷能力で攻撃することができるかもしれません。その一方で、人工知能が人間を殺すことの倫理的問題や、誤作動が生じた時の法的責任について議論

が続いています。もともと、すでに実際の戦場には多くの無人攻撃兵器が投入されています。私は将来、これらの無人攻撃兵器の有用さが社会に受け入れられ、国益に叶う活躍をすると考えています。私はこの研究を進めても良いのでしょうか？

16. あなたはこの研究について、賛成ですか、それとも反対ですか？
[1:とても賛成~7:とても反対]

17. この研究者は次に挙げる項目について、どの程度の配慮をする必要があると考えますか。あなたの考えにもっとも近いものに、チェックを入れてください。

*The matrix options are same as the first scenarios, and we omitted it here.

シナリオ4

私は情報科学分野の研究者です。AIの技術を使えば、個人のクレジットカードの使用履歴、防犯カメラ等から得られる行動履歴を分析することで、将来おきるであろう窃盗・殺人などの犯罪行為を高い精度で予測することができるかもしれません。この研究が進めば、さまざまな犯罪を未然に防ぐことや、犯罪を起こす可能性が高い人の行動を制限することができます。その一方で、個人情報の人々の監視のために使うことや、予測に基づいて人々の権利を制限することの是非も問われています。もともと、すでに個人の行動履歴等の情報はAIで分析され、マーケティングに活用されています。私は将来、個人のプライバシーに踏み込むAI技術も人々に受け入れられ、社会の安全・安心を守ることに大いに役立つと考えています。私はこの研究を進めても良いのでしょうか？

18. あなたはこの研究について、賛成ですか、それとも反対ですか？
[1:とても賛成~7:とても反対]

19. この研究者は次に挙げる項目について、どの程度の配慮をする必要があると考えますか。あなたの考えにもっとも近いものに、チェックを入れてください。

*The matrix options are same as the first scenarios, and we omitted it here.

Appendix C.

Table C3. The respondents' profile in marriage, occupation, house income, number of children, education, supporting political party, and usage of time for PC/smartphone.

Variables		N
Marriage	Single/unmarried	617
	Married/civil partnership	412
Occupation	Company employee	253
	Company officer or manager	72
	Civil servant or association staff member	71
	Self-employed	62
	Freelancer or professional	39
	Dispatch or contract employee	69
	Part-time worker	143
	Elementary school student and below	0
	Junior high school student	0
	High school student	0
	Preparatory school student	0
	Vocational school student, junior college student, university student, or graduate student	37
	Housewife or househusband	164
	Unemployed	105
	Other	14
House income	1,000,000JPY	51
	1,000,000JPY–2,000,000JPY	67
	2,000,000JPY–3,000,000JPY	118
	3,000,000JPY–4,000,000JPY	136
	4,000,000JPY–5,000,000JPY	147
	5,000,000JPY–6,000,000JPY	126
	6,000,000JPY–7,000,000JPY	78
	7,000,000JPY–8,000,000JPY	90
	8,000,000JPY–9,000,000JPY	39
	9,000,000JPY–10,000,000JPY	78
	10,000,000JPY–12,000,000JPY	48
	12,000,000JPY–15,000,000JPY	34
	15,000,000JPY–20,000,000JPY	8
	20,000,000JPY>	9
	Do not know	0
	Do not want to answer	0
Number of children	0	659
	1	196
	2	131
	3	32
	4 or more	11
Education	Elementary school/Junior high school	15
	High school	277
	Junior college/Vocational school	258
	University (undergraduate)	409
	University (graduate)	51
	Other	4
	I do not know	1
	I do not want to answer	14
Supporting political party	Liberal Democratic Party (自民党)	241
	The Constitutional Democratic Party of Japan (立憲民主党)	37
	Democratic Party For the People (国民民主党)	5
	Komeito (公明党)	19
	Japanese Communist Party (日本共産党)	19
	Nippon Ishin (日本維新の会)	53
	Social Democratic Party (社民党)	1
	The Party to Protect the People from NHK (NHKから国民を守る党)	6
	Reiwa Shinsengumi (れいわ新選組)	11
	Other political party	5
	I do not support any party	493
	I do not know	94
	I do not want to answer	45
Usage of time for PC/smartphone	Less than 30 minutes	37
	30 minutes to 1 hour	96
	1 hour to 2 hours	208
	2 hours to 3 hours	199
	3 hours to 4 hours	155
	4 hours to 6 hours	148
	6 hours to 8 hours	80
	8 hours to 10 hours	49
	10 hours or more	49
	I do not use them at all	8

The respondents' profile of marriage, occupation, house income, number of children were provided by the research company, which the respondents need to put when they registered this company. The profile of education, supporting political party and usage of time for PC/smartphone are our original items added in the questionnaire.