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ORIGINAL RESEARCH

# Segmentation of ethics, legal, and social issues (ELSI) related to AI in Japan, the United States, and Germany

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## Abstract

Artificial intelligence (AI) is often accompanied by public concern. In this study, we quantitatively evaluated a source of public concern using the framework for ethics, legal, and social issues (ELSI). Concern was compared among people in Japan, the United States, and Germany using four different scenarios: (1) the use of AI to replicate the voice of a famous deceased singer, (2) the use of AI for customer service, (3) the use of AI for autonomous weapons, and (4) the use of AI for preventing criminal activities. The results show that the most striking difference was in the response to the "weapon" scenario. Respondents from Japan showed greater concern than those in the other two countries. Older respondents had more concerns, and respondents who had a deeper understanding of AI were more likely to have concerns related to the legal aspects of it. We also found that attitudes toward legal issues were the key to segmenting their attitudes toward ELSI related to AI: Positive, Less skeptical of laws, Skeptical of laws, and Negative.

**Keywords** Artificial intelligence · AI · Scenario · ELSI · Concern

## 1 Introduction

Artificial intelligence (AI), currently being used in a wide range of fields, often raises public concern. The public has positive and negative attitudes, and they vary between countries. A global survey across 20 countries in 2020–21 reported that 53% of respondents agreed, at the median, that the development of AI had mostly been good for society. On the other hand, 33% thought that it had mostly been a bad thing for society [1]. Another global survey conducted in 2021 showed that 28% (somewhat disagree 16%, strongly disagree 12%) of respondents did not worry about AI, while 41% (strongly agree 15%, somewhat agree 26%) were worried about it. The negative responses toward AI varied across countries—France (53%), India (52%), the United States (45%), Germany (40%), Singapore (39%), and China (33%) [2]. Another global survey across 28 countries showed that people expected that AI would bring improvements to some parts of their lives, such as education and learning (77%), entertainment (77%), and transportation (74%), but less so for employment (47%) and cost of living (42%). The average number of respondents who agreed that AI had a positive impact on freedom and legal rights was low (37%), with agreement being especially low in the Netherlands (15%), Australia (16%), and the United States (16%) [3]. In Japan,

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people had higher anxiety than in the United States about AI ethics, especially for an AI weaponry scenario [4, 5].

There are various AI ethics policies from different countries [6]. Reporting on the differences in AI guidelines between Japan, the United States, and Europe [7] shows that Japan's guidelines emphasize promoting the dissemination of AI and decreasing people's concerns. In the United States, they emphasize the need to maximize the social benefits of AI and mention long-term risks, such as autonomous weapons. In Europe, the guidelines emphasize the rights and responsibilities of people. This indicates that ethical attitudes toward AI, a universal, advanced technology, vary between these countries. We believe that recognizing public attitudes about AI in different countries is increasingly important before deploying new AI technologies. In this study, we conducted an online survey to study public concern in four different contexts for AI in Japan, the United States, and Germany, and we compared the perceptions using audience segmentation based on our results.

Public attitudes vary in Japan, the United States, and Germany (Table 1). Asian countries, such as Japan, often have relatively positive views of AI in global surveys. For example, in one survey, 65% of Japanese respondents said that the development of AI had been a good thing for society. However, participants in the United States and Germany had different views of AI. In the same survey, only 47% of the United States and German respondents had positive attitudes [1]. Nitto et al. investigated the level of social acceptance of self-driving cars and AI-based phone operator systems in Japan, the United States, and Germany. They found that 59% of respondents in Japan and 61% in the United States were positive toward using self-driving cars, but respondents from Germany were less positive (49%). Positive views of AI-based phone operator systems were also higher in Japan (59%) and the United States (52%) than in Germany (43%) [8]. A 2019 German survey reported that 82% of participants had issues with the privacy of their data when using AI online [9]. Due to these differences in public attitudes, we decided that it would be valuable to compare Germany, the United States, and Japan to examine AI attitudes in more depth.

Some studies have shown that age is an informative sociographic variable across countries. Other studies have shown that the effect of interest in and knowledge of science and technology (S&T) on public concern about AI may depend on the context. People who are familiar with self-driving cars and have a good level of science literacy have lower levels of concern about self-driving vehicles in the United States [10]. In Japan, people who understand AI have shown a higher level of concern about the use of AI in crime prevention but did not show such concern for AI in entertainment [4, 5]. It is important to determine which variables have a stronger or weaker influence on AI issues when developing a better strategy to communicate with the public in different countries.

In this study, we focused on the framework for ethics, legal, and social issues (ELSI). The idea of ELSI was first introduced in the Human Genome Project in the United States in the 1990s. Of the total research budget, 3% (later 5%, at least) was allocated to research on ELSI issues. The ELSI, or ELSA (ethics, legal, social aspects) in Europe, program in life sciences started in other countries, for example, Canada in 2000, the United Kingdom in 2002, and Germany, Austria, and Finland in 2008. This idea was later used in many S&T fields, such as nanotechnology and brain science. In Europe, ELSA programs led to the concept of RRI (responsible research and innovation), which emphasizes a dialogue and engagement [e.g., [11]]. Even in the age of RRI, the importance of ELSI remains the same and is increasingly needed. In Japan, ELSI has gained attention over the past 15 years in the country's national S&T policy [12].

Hartwig et al. developed a test set consisting of four fictional AI scenarios (see Supplementary Appendix 1) and 13 questionnaire items about ELSI (see Supplementary Appendix 2) [5]. The respondents read the four dilemma scenarios based on real-life AI examples: (1) the use of AI to replicate the voice of a famous deceased singer (scenario "singer"), (2) the use of AI for customer service (scenario "service"), (3) the use of AI for autonomous weapons (scenario "weapon"), and (4) the use of AI for preventing criminal activities (scenario "crime"). Each scenario describes a situation in which an AI researcher is in a dilemma over whether to continue AI research after considering its advantages and disadvantages. Each scenario explicitly contains ethical and legal aspects, and social aspects implicitly. For example, in scenario "singer," the ethical and legal aspects are addressed by the sentence, "There is debate on the

**Table 1** Differences in public attitudes toward AI

| | Japan | United States | Germany |
|---|---|---|---|
| AI is good for society [1] | Positive (65% chose) | Rather negative (47% chose) | Rather negative (47% chose) |
| Self-driving car [8] | Positive (59% chose) | Positive (61% chose) | Rather negative (49% chose) |
| AI-based phone operator system [8] | Positive (59% chose) | Rather Positive (52% chose) | Negative (43% chose) |

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." This is written more explicitly in scenario "weapon." The ethical aspect is covered in the sentence, "There is the ethical question of AI killing people," and the legal aspect is addressed by "discussions regarding the legal liabilities in the event of a malfunction." Social aspects, which include cultural, traditional, religious, and public perspectives [5], are also included but not explicitly mentioned in the scenarios. The respondents then answered the 13 items using seven-point scale. The 13 items were later aggregated into only three items based on their importance: ethical (ethically very correct = 1 to ethically very incorrect = 7), traditional (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and legal (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7) [5]. Hartwig et al. developed this test set using data only from Japan and the United States [5].

Audience segmentation is useful for understanding public attitudes toward S&T in developing strategies for dialogue with the public [e.g., [13–15]]. Segmentation analysis classifies the public into relatively homogeneous and mutually exclusive subgroups [e.g., [16]] and can project high-dimensional survey data into simpler, low-dimensional segments. Iterations of segmentation enable an assessment of the time-series change for public attitudes. One example of this type of survey is the Victorian Segmentation (VSEG) method developed by the State of Victoria government in Australia. In 2011, a large percentage (37%) of Australians was assessed as "interested in science and who actively search for information," a 10% increase from 2007 (27%) [17]. In 2016, Schäfer et al. quantitatively segmented Swiss people using their perceptions of science and their information and media usage patterns into five groups: sciencephiles, critically interested, passive supporters, and disengaged [18]. Sciencephiles, or those who have a "strong interest for science, extensive knowledge, and a pronounced belief in its potential," and use a variety of sources intensively, were the dominant segment (27.8%) in Switzerland. This segmentation was also qualitatively investigated using smartphone-based media-use diaries and semi-structured interviews with 41 participants [19]. Three-year surveys using this segmentation in Switzerland showed that participants changed to more critical segments [20]. Comparisons of segmentation studies are not easy to carry out due to variations in item selection and methodological approaches. Füchslin emphasized the importance of the systematic application of segmentation analysis in science communication [21].

Recently, Bao et al. introduced audience segmentation into AI to assess public concerns [22]. The responses of 2700 in the United States in 2020 to 10 items about the likelihood of the possible risks and benefits of AI were analyzed using latent class analysis. This analysis identified five segments: negative (33.3%), ambivalent (28.5%), tepid (24.0%), ambiguous (7.5%), and indifferent (6.6%). Most responses were in the negative segment, or those who perceived that the risks of AI outweighed the benefits. They showed more negative attitudes toward technology in general, especially low control over data use. Kelly et al. qualitatively segmented the public perception of AI across eight countries based on an open-ended online questionnaire and identified four groups: exciting (showed positive feelings about AI and exhibited excitement, 18.9%), useful (had a belief that AI would be helpful and assist humans, 12.2%), worrying (had negative emotional responses, such as concern and fear, 22.7%), and futuristic (mentioned the futuristic nature of AI, 24.4%) [23]. Segmenting the audience using data from Japan, the United States, and Germany would be useful for visualizing the differences in people's attitudes toward AI ethics. As a result, we decided to combine audience segmentation of ELSI related to AI with scenario-based surveys.

### 1.1 Research questions

We believe that identifying potential ELSI areas of improvement before deploying new AI technologies to work with the concerned public is important to adapt AI to society's preferences. In this study, we collected data from Japan, the United States, and Germany, motivated by differences in public and social attitudes toward AI. In addition to the ELSI attitudes for the four scenarios developed by Hartwig et al. [5], we conducted audience segmentation. The research questions in this study were as follows:

RQ1: What are the differences in public ELSI concerns about AI in Japan, the United States, and Germany?
RQ2: Which variables are most likely to be related to the public's AI concerns across countries?
RQ3: How can respondents be segmented?

## 2 Methodology

We asked respondents from Japan, the United States, and Germany to answer questions in an online survey to show their ELSI concerns with each scenario. We also investigated how sociodemographic variables, the level of interest in S&T, and the understanding of AI influenced respondents' concerns about AI ethics.

## 2.1 Respondents

We contracted Cross Marketing Inc., a research company in Japan, to collect data from Japan, the United States, and Germany using their data pool. For Japan, the company collected data from 1075 respondents (men = 514, women = 561) aged 20–69 years (mean ± SD = 45.3 ± 13.6). The survey was conducted from June 2 to 8, 2021. For the United States, the company collected data from June 2–10, 2021, from 1095 respondents (men = 537, women = 558) aged 20–69 years (mean ± SD = 44.7 ± 14.7). For Germany, the company collected data from 1086 respondents (men = 539, women = 547) aged 20–69 years (mean ± SD = 45.6 ± 14.5). The survey was also conducted from June 2 to 10, 2021. The samples in all three countries matched the current demographic profile of that country's population for age, gender, and location. Our study received approval from the Institutional Ethics Committee of the University of Tokyo (No. 21-78).

## 2.2 Procedure

The online questionnaire consisted of (1) sociodemographic variables, (2) the level of interest in S&T, (3) the understanding of AI, and (4) questionnaire items for each scenario. To ensure accuracy, we prepared the questionnaire in Japanese, English, and German using double-back translations from Japanese to English, English to Japanese, English to German, and German to English.

1. Sociodemographic variables—age, gender, location, education, occupation, and household income (see Supplementary Appendix 3): We included age, gender, and education in our analysis. The responses to education were categorized as "more than university," including "university" and "graduate school;" "other," including "elementary school/junior high school" and "high school/junior college/vocational school;" "other;" "do not know;" and "do not want to answer."
2. Level of interest in S&T: We used the VSEG segmentation method to classify the level of interest in S&T. The respondents answered three items (ST1, ST2, and ST3 below) that were classified into six segments [17, 24, 25] with three groups (with interest, with potential interest, with low interest) by combining the responses to the three items (Table 2). Segments 2 and 3 were considered a group that had interest in S&T; Segments 1, 6, and 4 were considered a group that had potential interest in S&T; and Segment 5 was a group with low interest [26].

- ST1. How much are you interested in science and technology? (1: Very interested, 2: Quite interested, 3: Neither interested nor disinterested, 4: Not very interested, 5: Not interested at all, 6: Don't know.)
- ST2. Do you actively search for information about science and technology? (1: Yes, 2: No, 3: Don't know.)
- ST3: 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? (1: Yes, and it tends to be easy to understand; 2: Yes, but it is often difficult to understand; 3: No, I often can't find what I am looking for; 4: Don't know.)

**Table 2** Three groups based on the Victorian Segment (VSEG)

| | Group with interest | Group with potential interest | Group with low interest |
|---|---|---|---|
| ST1 | 1 or 2 | 1, 2, 3, 4, or 5 | 4 or 5 |
| ST2 | 1 | 1 or 2 | 2 |
| ST3 | 1, 2 or 3 | – | – |

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

3. Understanding of AI: We prepared four short quizzes to measure the level of understanding of AI. A set of quizzes (1 to 3) was used in a previous study [4, 5]. However, we added a fourth question (4) to improve the reliability of this set of quizzes. The quizzes were as follows:

- Quiz 1: 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.) The correct answer is 2.
- Quiz 2: 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.) The correct answer is 2.
- Quiz 3: 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.) The correct answer is 2.
- Quiz 4: Which of the following options is the most appropriate statement about the performance of current AI technology compared to the performance of humans on various tasks? (1: The performance of AI is always better than the performance of humans on all tasks, 2: The performance of AI and humans is identical on all tasks, 3: The performance of AI is better than the per-

formance of humans on some tasks, 4: The performance of AI is never better than the performance of humans on any task.) The correct answer is 3.

4. Questionnaire items for each scenario: There were four different scenarios [(a)–(d) (see Supplementary Appendix 1)]. Each scenario described the use of AI for AI-generated singers (scenario "singer"), AI customer purchases (scenario "service"), AI autonomous weapons (scenario "weapon"), and AI prediction of criminal activities (scenario "crime"). The scenarios consisted of a description of the beneficial and anxiety-inducing aspects of AI from the viewpoint of the researchers. The last sentence "May I continue on with this research?" shows that the researcher faces an ethical dilemma: whether or not to continue their work (Fig. 1).

After reading each scenario, we asked the respondents to give their thoughts on this AI research from the viewpoint of Ethics (Ethically very correct = 1 to Ethically very incorrect = 7, Q1), Tradition (Extremely favorable from a traditional perspective = 1 to Extremely unfavorable from a traditional perspective = 7, Q2), and Laws (Policies and laws are sufficiently established = 1 to Policies and laws are insufficiently established = 7, Q3). These three items were statistically reduced from 13 items using ELSI [5]. The respondents rated the items on a seven-point scale (Table 3).

# 3 Results

## 3.1 Differences among countries and variables related to ELSI

We conducted a linear regression to investigate the relationship between the responses to the use of AI (Q1–Q3, dependent variables) and the independent variables for each scenario. There were six independent variables: country (the United States served as the baseline), age, gender (men served as the baseline), education (other served as the baseline), interest in S&T (group with high interest served as the baseline), and the number of correct answers to the AI quiz. The number of responses for each variable is shown in Supplementary Appendix 3. This analysis was conducted using IBM SPSS Statistics 25 software.

### 3.1.1 Scenario "singer"

The distribution of the scales is shown in Fig. 2. The averages of the scales are shown in Supplementary Appendix 4. Most Japanese respondents chose the middle of the scale (scale 4) for ethics, tradition, and laws. This demonstrates that the majority of Japanese respondents chose

**Fig. 1** Scenario "service"

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. — Positive and negative aspect

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. — Current situation

May I continue on with this research?

**Table 3** Questionnaire design of Q1–Q3

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Q1. Ethically very correct | | | | | | | | Ethically very incorrect |
| Q2. Extremely favorable from a traditional perspective | | | | | | | | Extremely unfavorable from a traditional perspective |
| Q3. Policies and laws are sufficiently established | | | | | | | | Policies and laws are insufficiently established |

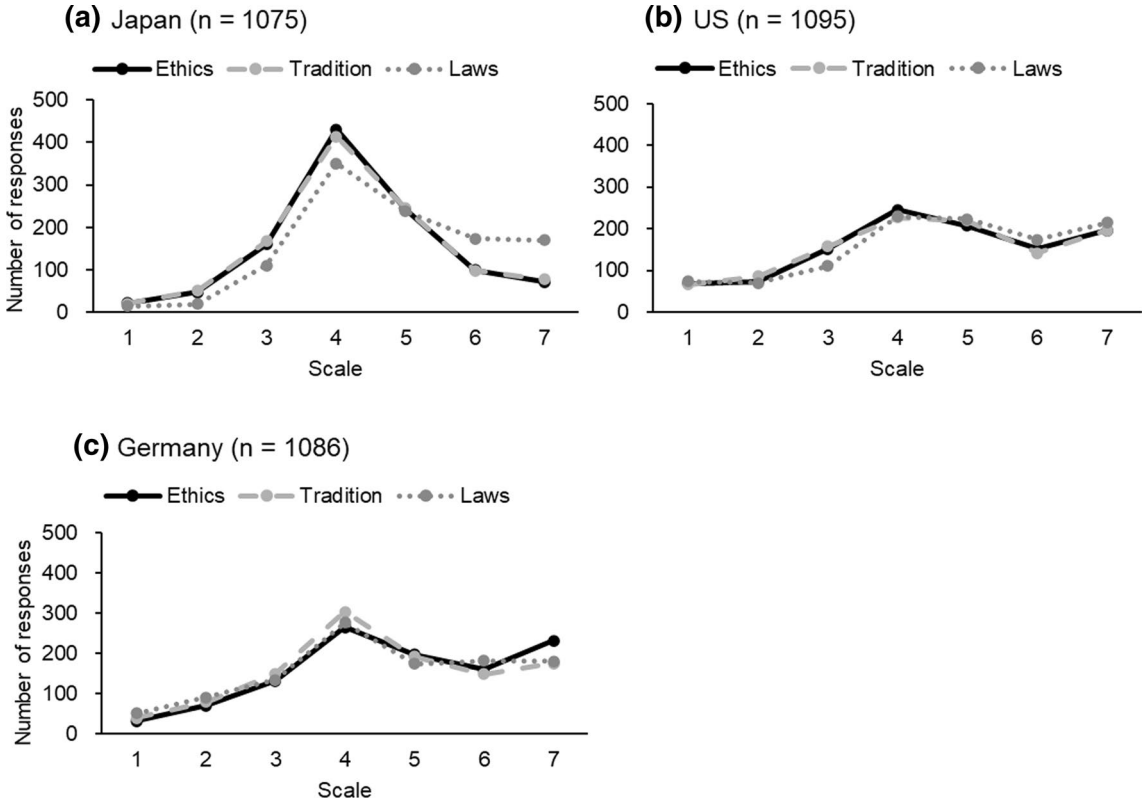


**Fig. 2** Responses to scenario "singer" in Japan (**a**), the United States (**b**) and Germany (**c**). Lower scale shows less concern and higher scale shows high concern: ethics (ethically very correct = 1 to ethically very incorrect = 7), tradition (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and laws (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7)

the middle option. The responses in the United States and Germany were relatively evenly distributed for all scales (Fig. 2b, c).

The standardization coefficient ($\beta$) of a country for ethics and tradition was statistically significant between two countries more than once, but not for laws (Table 4). More respondents from Germany and the United States were concerned about ethics than in Japan. German respondents were also more concerned about ethics than respondents in the United States, and respondents from Germany and the United States were more concerned about tradition than those in Japan. Age was statistically significant for ethics, tradition, and laws, suggesting that older people were more concerned than young people with all three points. The AI quiz was also statistically significant for ethics, tradition, and laws, suggesting that people who knew about AI were more likely to be concerned than those with little AI knowledge. Gender was statistically significant for ethics and tradition, suggesting that women were more concerned than men. The VSEG was also statistically significant for ethics and tradition, implying that respondents in the group with potential and low interest were more concerned than those in the group with high interest.

#### 3.1.2 Scenario "service"

The distribution of the scales is shown in Fig. 3. The averages of the scales are shown in Supplementary Appendix 4. Most of the respondents in Japan, the United States, and Germany chose the middle option (scale 4) for ethics, tradition, and laws.

The standardization coefficient ($\beta$) of a country for ethics and laws was statistically significant between two countries more than once, but not for tradition (Table 5). German respondents were more concerned about ethics than those in the United States. Japanese respondents were more concerned about laws than people from the United States. Age was statistically significant for ethics, tradition, and laws, suggesting that older people were more concerned than young people about all three points. Education was statistically significant only for laws, implying that those who had graduated from university were more concerned than others. The AI quiz was only statistically significant for laws, suggesting that those respondents who understood AI were more likely to be concerned than those without an understanding of it. The VSEG was statistically significant for ethics and tradition, meaning that people in the group

**Table 4** Statistical results in scenario "singer"

| Variable | Explanation of variable | Raw means | Ethics | | | | Tradition | | | | Laws | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | |
| | | | | | Lower | Upper | | | Lower | Upper | | | Lower | Upper |
| Country | = 1 if Japan, 0 if the U.S | 33.0% | − 0.10 | 0.000* | − 0.48 | − 0.20 | − 0.09 | 0.000* | − 0.43 | − 0.16 | 0.03 | 0.166 | − 0.04 | 0.24 |
| | = 1 if Germany, 0 if the U.S | 33.4% | 0.06 | 0.002* | 0.08 | 0.34 | 0.00 | 0.978 | − 0.13 | 0.13 | − 0.03 | 0.142 | − 0.24 | 0.03 |
| | = 1 if Germany, 0 if Japan | | 0.10 | 0.000* | 0.20 | 0.48 | 0.09 | 0.000* | 0.16 | 0.44 | − 0.03 | 0.17 | − 0.24 | 0.04 |
| Age | Year of age | 45.2 ± 14.3 | 0.15 | 0.000* | 0.01 | 0.02 | 0.13 | 0.000* | 0.01 | 0.02 | 0.17 | 0.000* | 0.02 | 0.02 |
| Gender | = 1 if women, 0 if men | 51.2% | 0.05 | 0.002* | 0.06 | 0.28 | 0.06 | 0.001* | 0.08 | 0.30 | 0.03 | 0.057 | 0.00 | 0.22 |
| Education | = 1 if "more than university", 0 if "others" | 67.2% | 0.00 | 0.854 | − 0.10 | 0.12 | 0.01 | 0.704 | − 0.09 | 0.14 | 0.06 | 0.001* | 0.09 | 0.32 |
| VSEG | = 1 if NA, 0 if High | 8.5% | 0.02 | 0.282 | − 0.09 | 0.33 | 0.01 | 0.599 | − 0.15 | 0.27 | − 0.02 | 0.219 | − 0.35 | 0.08 |
| | = 1 if low, 0 if High | 12.62% | 0.07 | 0.001* | 0.14 | 0.50 | 0.05 | 0.006* | 0.08 | 0.44 | 0.01 | 0.529 | − 0.13 | 0.24 |
| | = 1 if potential, 0 if High | 33.8% | 0.07 | 0.000* | 0.10 | 0.35 | 0.08 | 0.000* | 0.13 | 0.38 | 0.03 | 0.134 | − 0.03 | 0.23 |
| AI quiz | Number of correct answers | 2.6 ± 1.2 | 0.06 | 0.001* | 0.03 | 0.12 | 0.06 | 0.001* | 0.03 | 0.13 | 0.13 | 0.000* | 0.13 | 0.22 |
| $R^2$ | | | 0.05 | | | | 0.04 | | | | 0.07 | | | |

Raw means show the percentage or the average ± SD. Results from linear logistic regression. β shows standardization coefficient

95% CI shows 95% Confidence Interval

*$p < 0.05$

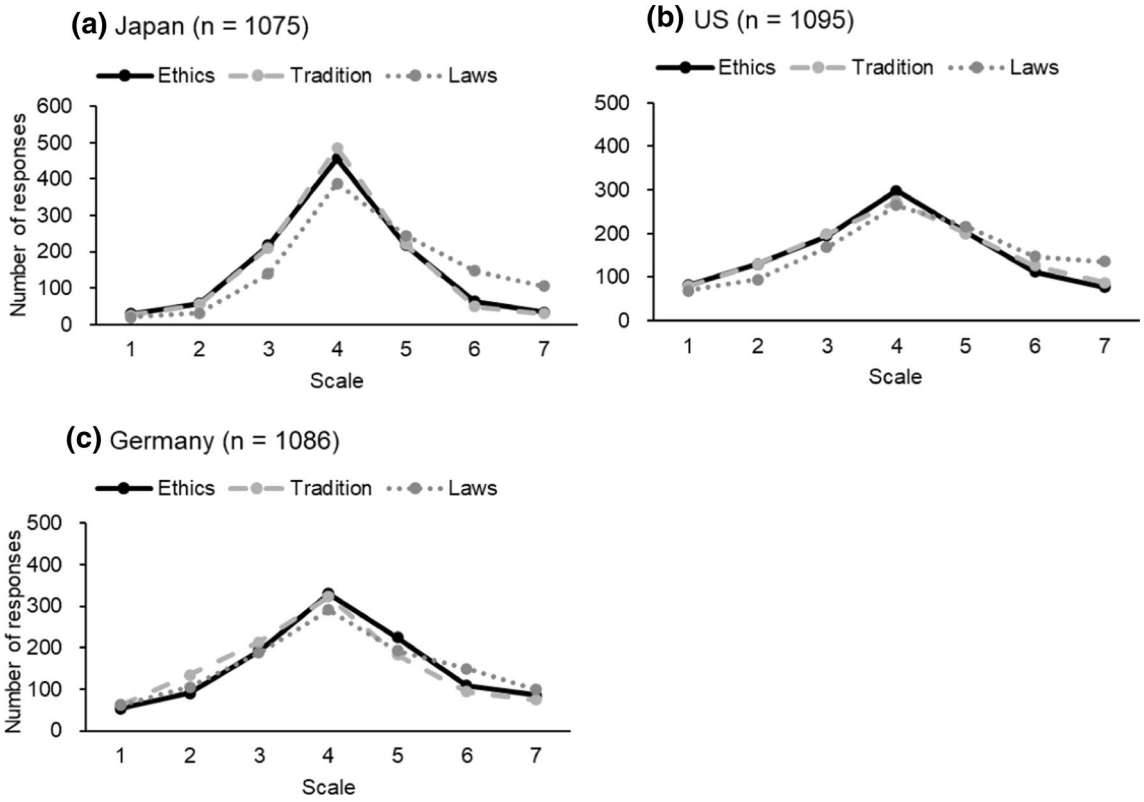


**Fig. 3** Responses to scenario "service" in Japan (**a**), the United States (**b**) and Germany (**c**). Lower scale shows less concern and higher scale shows high concern: ethics (ethically very correct = 1 to ethically very incorrect = 7), tradition (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and laws (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7)

with potential and low interest were more concerned than the group with high interest.

#### 3.1.3 Scenario "weapon"

The distribution of the scales is shown in Fig. 4. The averages of the scales are shown in Supplementary Appendix 4. Most Japanese chose the middle option (scale 4) for ethics and tradition, but they chose the most concerned option (scale 7) for laws. Most of the respondents from the United States chose the middle option for ethics, tradition, and laws. Most Germans chose the middle option for tradition and laws, but they chose the most concerned option for ethics.

The standardization coefficient ($\beta$) of a country for ethics, tradition, and laws was statistically significant between two countries more than once (Table 6). Respondents from Japan and Germany were more concerned about ethics than those from the United States. Japanese respondents were more concerned about ethics than those from Germany and were more concerned with tradition and laws than respondents from the United States and Germany. Age was statistically significant for ethics, tradition, and laws, suggesting that older people were more concerned than young people about all three points. Gender and the AI quiz were statistically significant for all three points, which suggests that women were more concerned than men, and people who understood AI were more concerned than those with little AI knowledge. Education was statistically significant only for laws, meaning that those who had graduated from university were more concerned than others. The VSEG was statistically significant for ethics and tradition, suggesting that respondents in the group with potential interest were more concerned than those in the group with high interest.

#### 3.1.4 Scenario "crime"

The distribution of the scales is shown in Fig. 5. The averages of the scales are shown in Supplementary Appendix 4. The majority of Japanese and German respondents chose the middle option (scale 4) for ethics, tradition, and laws. In the United States, as many respondents chose the most concerned option (scale 7) as the middle option for laws.

The standardization coefficient ($\beta$) of a country for ethics, tradition, and laws was statistically significant between two countries more than once (Table 7). More respondents from the United States showed their concern about ethics and

**Table 5** Statistical results in scenario "service"

| Variable | Explanation of variable | Raw means | Ethics | | | | Tradition | | | | Laws | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | |
| | | | | | Lower | Upper | | | Lower | Upper | | | Lower | Upper |
| Country | = 1 if Japan, 0 if the U.S | 33.0% | − 0.02 | 0.453 | − 0.18 | 0.08 | − 0.03 | 0.113 | − 0.23 | 0.02 | 0.05 | 0.023* | 0.02 | 0.30 |
| | = 1 if Germany, 0 if the U.S | 33.4% | 0.06 | 0.006* | 0.05 | 0.29 | − 0.04 | 0.056 | − 0.24 | 0.00 | − 0.04 | 0.054 | − 0.26 | 0.00 |
| | = 1 if Germany, 0 if Japan | | 0.02 | 0.453 | − 0.08 | 0.18 | 0.03 | 0.113 | − 0.03 | 0.23 | − 0.05 | 0.023 | − 0.30 | − 0.02 |
| Age | Year of age | 45.2 ± 14.3 | 0.11 | 0.000* | 0.01 | 0.01 | 0.10 | 0.000* | 0.01 | 0.01 | 0.16 | 0.000* | 0.01 | 0.02 |
| Gender | = 1 if women, 0 if men | 51.2% | 0.00 | 0.917 | − 0.09 | 0.11 | 0.00 | 0.868 | − 0.09 | 0.11 | − 0.01 | 0.757 | − 0.12 | 0.09 |
| Education | = 1 if "more than university", 0 if "others" | 67.2% | 0.00 | 0.854 | − 0.10 | 0.12 | − 0.02 | 0.342 | − 0.16 | 0.05 | 0.05 | 0.003* | 0.06 | 0.28 |
| VSEG | = 1 if NA, 0 if High | 8.5% | 0.07 | 0.000* | 0.16 | 0.55 | 0.04 | 0.040* | 0.01 | 0.40 | 0.01 | 0.590* | − 0.15 | 0.26 |
| | = 1 if low, 0 if High | 12.62% | 0.08 | 0.000* | 0.18 | 0.51 | 0.08 | 0.000* | 0.16 | 0.50 | 0.03 | 0.119 | − 0.04 | 0.32 |
| | = 1 if potential, 0 if High | 33.8% | 0.09 | 0.000* | 0.17 | 0.40 | 0.10 | 0.000* | 0.19 | 0.42 | 0.04 | 0.053 | 0.00 | 0.25 |
| AI quiz | Number of correct answers | 2.6 ± 1.2 | − 0.03 | 0.078 | − 0.08 | 0.00 | − 0.02 | 0.246 | − 0.07 | 0.02 | 0.06 | 0.001* | 0.03 | 0.12 |
| $R^2$ | | | 0.03 | | | | 0.02 | | | | 0.05 | | | |

Raw means show the percentage or the average ± SD. Results from linear logistic regression. β shows standardization coefficient

95% CI shows 95% Confidence Interval

*$p < 0.05$

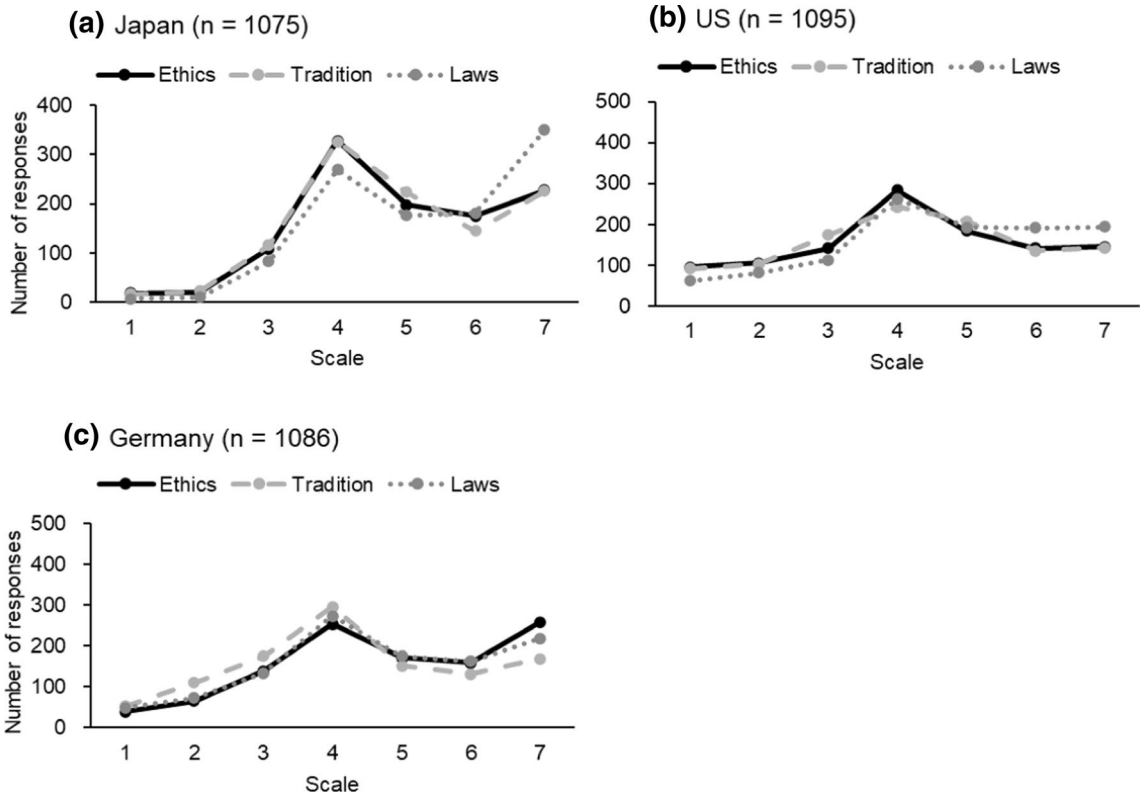


**Fig. 4** Responses to scenario "weapon" in Japan (**a**), the United States (**b**) and Germany (**c**). Lower scale shows less concern and higher scale shows high concern: ethics (ethically very correct = 1 to ethically very incorrect = 7), tradition (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and laws (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7)

tradition than in the other two countries and were more concerned about laws than respondents from Germany. Age was statistically significant for ethics, tradition, and laws, suggesting that older people were more concerned than young people about all three points. The AI quiz was also statistically significant for all three points, suggesting that people who understood AI were more concerned than those with little AI knowledge. Education was statistically significant only for laws, meaning that those who had graduated from university were more concerned than the others. The VSEG was statistically significant for ethics and tradition, suggesting that people in the group with potential and low interest were more concerned than the group with high interest.

## 3.2 Segmentation (ELSI segment)

In the previous section, we presented an analysis of the results separated by scenarios and countries. Next, we analyzed all the data to find any general trends or tendencies. Revealing these trends allowed us to find subgroups of respondents independent of country and scenario, allowing us to generalize these results.

For this part of the analysis, we used the three dimensions: ethics (ethically very correct = 1 to ethically very incorrect = 7), tradition (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and laws (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7). Each participant replied to these three questions on a scale of 1–7 for the four scenarios. Therefore, each participant provided four data points in a 3D space (one per scenario), which we combined to produce a 3D cube of 13,024 individual points.

We then used K-means clustering to segment the data into subgroups. K-means clustering is an unsupervised learning method that iteratively finds the optimal positions of cluster centroids so that the sum of the distances of the nearest neighbors to the centroids is minimized. The desired number of clusters is a free parameter, which we set at four. This choice was motivated by three reasons. First, four clusters is the first configuration, where we found nontrivial groups. Second, we wanted to assign meaning to each of these groups, and too many groups would limit the interpretability of the results. Third, we used the Bayesian Information Criterion (BIC) to find the optimal model. The BIC quantifies

**Table 6** Statistical results in scenario "weapon"

| Variable | Explanation of variable | Raw means | Ethics | | | | Tradition | | | | Laws | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | |
| | | | | | Lower | Upper | | | Lower | Upper | | | Lower | Upper |
| Country | = 1 if Japan, 0 if the U.S | 33.0% | 0.17 | 0.000* | 0.47 | 0.77 | 0.18 | 0.000* | 0.49 | 0.78 | 0.19 | 0.000* | 0.52 | 0.80 |
| | = 1 if Germany, 0 if the U.S | 33.4% | 0.16 | 0.000* | 0.42 | 0.70 | 0.03 | 0.194 | − 0.05 | 0.23 | 0.01 | 0.444 | − 0.08 | 0.19 |
| | = 1 if Germany, 0 if Japan | | − 0.17 | 0.000* | − 0.77 | − 0.47 | − 0.18 | 0.000* | − 0.78 | − 0.49 | − 0.19 | 0.000* | − 0.80 | − 0.52 |
| Age | Year of age | 45.2 ± 14.3 | 0.13 | 0.000* | 0.01 | 0.02 | 0.11 | 0.000* | 0.01 | 0.02 | 0.14 | 0.000* | 0.01 | 0.02 |
| Gender | = 1 if women, 0 if men | 51.2% | 0.04 | 0.042* | 0.00 | 0.23 | 0.06 | 0.000* | 0.09 | 0.32 | 0.04 | 0.014* | 0.03 | 0.25 |
| Education | = 1 if "more than university", 0 if "others" | 67.2% | 0.04 | 0.051 | 0.00 | 0.24 | 0.01 | 0.571 | − 0.09 | 0.16 | 0.06 | 0.000* | 0.10 | 0.33 |
| VSEG | = 1 if NA, 0 if High | 8.5% | 0.00 | 0.949 | − 0.21 | 0.23 | − 0.02 | 0.349 | − 0.33 | 0.12 | − 0.03 | 0.129 | − 0.38 | 0.05 |
| | = 1 if low, 0 if High | 12.62% | 0.03 | 0.078 | − 0.02 | 0.36 | 0.00 | 0.870 | − 0.18 | 0.21 | 0.00 | 0.936 | − 0.19 | 0.18 |
| | = 1 if potential, 0 if High | 33.8% | 0.06 | 0.001* | 0.09 | 0.35 | 0.05 | 0.008* | 0.05 | 0.31 | 0.02 | 0.246 | − 0.05 | 0.20 |
| AI quiz | Number of correct answers | 2.6 ± 1.2 | 0.10 | 0.000* | 0.09 | 0.19 | 0.08 | 0.000* | 0.06 | 0.16 | 0.18 | 0.000* | 0.20 | 0.30 |
| $R^2$ | | | 0.07 | | | | 0.06 | | | | 0.11 | | | |

Raw means show the percentage or the average ± SD. Results from linear logistic regression. β shows standardization coefficient

95% CI shows 95% Confidence Interval

*$p < 0.05$

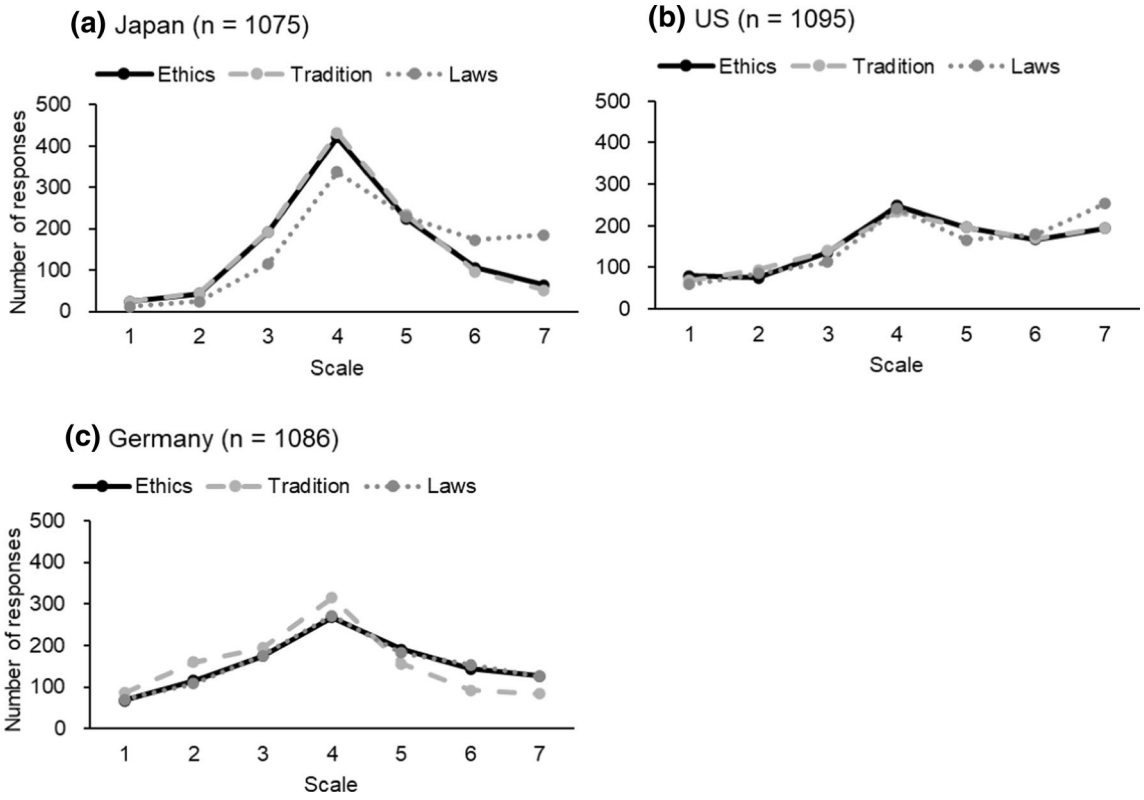


**Fig. 5** Response to the scenario "crime" in Japan (**a**), the United States (**b**) and Germany (**c**). Lower scale shows less concern and higher scale shows high concern: ethics (ethically very correct = 1 to ethically very incorrect = 7), tradition (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and laws (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7)

the balance between model complexity and data fitting. We found a local optimum for four clusters and concluded that it was best to divide the data into four clusters. The four segments are shown in Fig. 6.

Group 1 (light blue, 17%) showed very positive opinions toward AI research, and Group 4 (orange, 22%) showed very negative attitudes toward AI research. Group 2 (red, 33%) and Group 3 (dark blue, 28%) showed answers in the middle of the scale. K-means clustering suggests that these middle groups were divided based on law. Group 2 thought that "policies and laws are sufficiently established," and Group 3 was more skeptical, thinking that "policies and laws are insufficiently established." The rules for our segmentation are shown in Table 8. The division based on Laws is a result of unsupervised clustering. It does not necessarily imply that the respondents' opinions about laws and policies were more controversial in these two groups.

Once these segments were established, we were able to analyze the replies within these groups. Figure 7 shows each country's representation in the four segments. Japan was strongly represented in the two central groups (Groups 2 and 3), which is related to concern with Laws. Twice as many Japanese people were in Group 4 (Negative) than in Group 1 (Positive). The United States was equally distributed among all groups. Germany was the only country with an asymmetry between Groups 2 and 3. More German people were in Group 2 (Less skeptical of laws) than in Group 3 (Skeptical of laws).

### 3.3 Findings

RQ1: In scenario "singer," Germany and the United States had ethical (ethics) and social (tradition) concerns. In scenario "service," Germany had ethical concerns, and Japan had legal and policy concerns (laws). In scenario "weapon," Japan and Germany had ethical concerns, and Japan also had social and legal and policy concerns. In scenario "crime," the United States had ethical, social, and legal and policy concerns.

RQ2: Age was statistically related to ethics, tradition, and laws issues of AI. Older respondents were more concerned about the use of AI than younger respondents. The level of understanding of AI was also statistically related to legal issues. Those who understood AI had more issues with laws and policies than those who did not.

**Table 7** Statistical results in scenario "crime"

| Variable | Explanation of variable | Raw means | Ethics | | | | Tradition | | | | Laws | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\beta$ | $P$ | 95% CI | | $\beta$ | $p$ | 95% CI | | $\beta$ | $p$ | 95% CI | |
| | | | | | Lower | Upper | | | Lower | Upper | | | Lower | Upper |
| Country | = 1 if Japan, 0 if the U.S | 33.0% | − 0.11 | 0.000* | − 0.52 | − 0.24 | − 0.12 | 0.000* | − 0.56 | − 0.28 | 0.01 | 0.477 | − 0.09 | 0.20 |
| | = 1 if Germany, 0 if the U.S | 33.4% | − 0.10 | 0.000* | − 0.47 | − 0.20 | − 0.22 | 0.000* | − 0.86 | − 0.60 | − 0.14 | 0.000* | − 0.63 | − 0.36 |
| | = 1 if Germany, 0 if Japan | | 0.11 | 0.000* | 0.24 | 0.52 | 0.12 | 0.000* | 0.28 | 0.56 | − 0.02 | 0.477 | − 0.20 | 0.09 |
| Age | Year of age | 45.2 ± 14.3 | 0.07 | 0.000* | 0.00 | 0.01 | 0.05 | 0.007* | 0.00 | 0.01 | 0.13 | 0.000* | 0.01 | 0.02 |
| Gender | = 1 if women, 0 if men | 51.2% | − 0.01 | 0.449 | − 0.15 | 0.07 | − 0.01 | 0.551 | − 0.14 | 0.08 | − 0.03 | 0.051 | − 0.22 | 0.00 |
| Education | = 1 if "more than university", 0 if "others" | 67.2% | 0.00 | 0.941 | − 0.12 | 0.11 | − 0.01 | 0.726 | − 0.14 | 0.09 | 0.05 | 0.005* | 0.05 | 0.29 |
| VSEG | = 1 if NA, 0 if High | 8.5% | 0.03 | 0.184 | − 0.07 | 0.36 | 0.01 | 0.438 | − 0.13 | 0.30 | 0.00 | 0.935 | − 0.21 | 0.23 |
| | = 1 if low, 0 if High | 12.62% | 0.05 | 0.009* | 0.06 | 0.44 | 0.05 | 0.018* | 0.04 | 0.40 | 0.01 | 0.677 | − 0.15 | 0.23 |
| | = 1 if potential, 0 if High | 33.8% | 0.05 | 0.020* | 0.02 | 0.28 | 0.06 | 0.002* | 0.08 | 0.33 | 0.00 | 0.814 | − 0.12 | 0.15 |
| AI quiz | Number of correct answers | 2.6 ± 1.2 | 0.09 | | 0.07 | 0.16 | 0.08 | | 0.05 | 0.15 | 0.13 | | 0.14 | 0.23 |
| $R^2$ | | | 0.02 | 0.000* | | | 0.05 | 0.000* | | | 0.07 | 0.000* | | |

Raw means show the percentage or the average ± SD. Results from linear logistic regression. $\beta$ shows standardization coefficient

95% CI shows 95% Confidence Interval

*$p < 0.05$

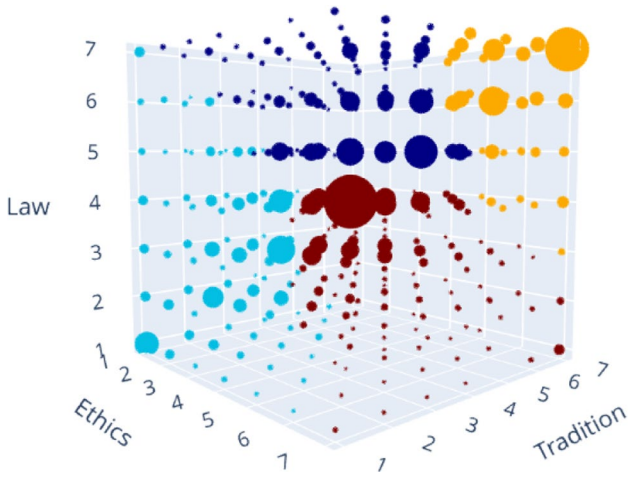


**Fig. 6** All survey data segmented into four groups with k-means clustering. The size of the points indicates how many people replied to this combination and the colors represent the four segments. Lower scale shows less concern and higher scale shows high concern: ethics (ethically very correct = 1 to ethically very incorrect = 7), tradition (extremely favorable from a traditional perspective = 1 to extremely unfavorable from a traditional perspective = 7), and laws (policies and laws are sufficiently established = 1 to policies and laws are insufficiently established = 7)

**Table 8** Rule for segmentation

| Ethics + Tradition + Law | Group | |
|---|---|---|
| < 10 | Group 1(Positive) | |
| 10–16 | Law < = 4<br>Group 2<br>(Less skeptical of laws) | Law > 4<br>Group 3<br>(Skeptical of laws) |
| > 16 | Group 4 (Negative) | |

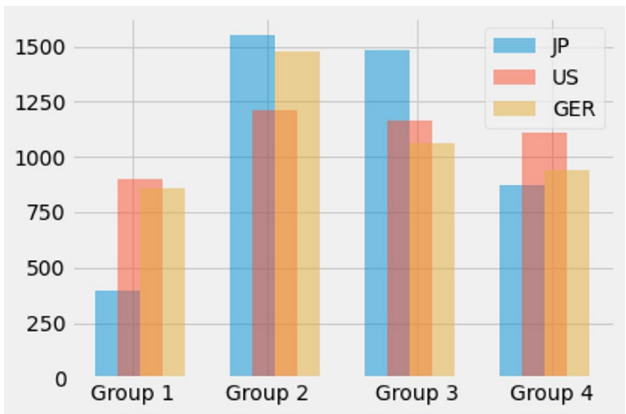


**Fig. 7** Distribution of the numbers for four segments in Japan, the United States and Germany

RQ3: The respondents were segmented into four groups: Positive, Less skeptical of laws, Skeptical of laws, and Negative.

## 4 Discussion

In this study, we investigated public concern about ELSI related to AI in Japan, the United States, and Germany. From RQ1, it was clear that public concern about ELSI differed in each country. The results show that a certain percentage of respondents in each country objected to conducting AI research in the designated four scenarios on ethical, traditional, and legal grounds.

The most striking example was the response to the "weapon" scenario. In that scenario, Japanese respondents replied more frequently with "ethically incorrect," "unfavorable from a traditional perspective," and "policies and laws are insufficiently established" (Table 6, Supplementary Appendix 1) compared to the other two countries. This result is consistent with previous studies that show that the Japanese are more concerned about scenario "weapon" than people from the United States [4, 5]. This result might be interpreted as Japanese people having ELSI concerns related to the use of AI during a war or from war itself, although the scenario did not clearly suggest warfare. It is not clear from this study alone why the Japanese have these concerns, but, for example, the existence of Article 9 of the Japanese Constitution prescribing the renunciation of war may bolster the negative perception of using AI during war.

For scenario "singer," Japanese respondents showed less concern about ethics and tradition than Germany and the United States (Table 4). This difference may be caused by the Japanese being less likely to feel concerned about things that have already been achieved. For example, in Japan, Misora Hibari, a famous Japanese singer who died in 1989, was "revived" using AI in 2019. The AI-Misora Hibari performed a new song on a famous Japanese TV program, which had a 37% TV viewing rating [27, 28]. Many Japanese are aware of singers being replicated using AI, and their responses to AI-Misora Hibari varied. It would be useful to observe the response to AI-generated singers "performing" in other countries. Another possibility is the difference in the perception of an artificial presence, such as AI-generated singers. One study reported that Japanese people often associate the word *robot* with a humanoid robot that can communicate with people. People in the United States, on the other hand, frequently use the word *robot* in their homes and retail stores. However, Germans perceive *robots* as being used in industry, and they strongly resist using robots in their homes [8]. Although humanoid robots and AI-generated singers are not the same, Japanese people may be more receptive to a human-like artificial presence than Germans and Americans.

However, a recent Japanese study indicated that it is doubtful that the Japanese have a different animistic and friendlier attitude toward robots (not limited to humanoid robots) than Westerners [29]. Another interesting observation is that there is no significant difference among countries on laws (Table 4), even though regulations on AI vary. Entertainment is a global field, where the public expects that AI will be used [3], possibly because they feel that they will not enjoy this type of entertainment if it is strictly regulated.

With regard to RQ2, age and understanding of AI were significantly related to public ELSI concerns (Tables 4, 5, 6, and 7). Older people showed more concern about the use of AI than younger people, which was observed across the four scenarios and the three perspectives. This trend is consistent with previous studies in Japan and the United States [4, 5]. Another study also reported that older Germans were more concerned than younger Germans about data privacy in algorithmic personalization [30]. It remains unclear whether this is a generational or an age issue. We need to examine from a young age how the concerns of a generation that is more familiar with AI change as they age. Those people who have a higher understanding of AI are more concerned laws (Tables 4, 5, 6, and 7). People who understand AI understand the power and possible problems of AI applications. Therefore, they may have stronger expectations for the political regulation of AI through laws and policies. We found a conflicting relationship between knowledge of AI and interest in S&T. With more AI knowledge, people become more *negative* toward AI, but with more interest in S&T, people become more *positive* toward it. This trend was observed for ethics and tradition across three scenarios, but not the scenario "service." Looking at interest in S&T, similar results have been reported in the United States—people who are optimistic about technological development are about twice as likely to accept new technologies, such as personal drones and robot caregivers, than those who are pessimistic [31]. One possible explanation for this difference is that knowledge of AI is evaluated objectively, but the level of interest in S&T is self-reported.

For RQ3, we segmented the respondents into four groups (Table 8): Group 1 (total points > 16, Positive), Group 2 (total points < 10, Less skeptical of Laws), Group 3 (total points from 10 to 16, Skeptical of Laws), and Group 4 (total points from 10 to 16, Negative). The intermediate responses (Groups 2 and 3) were divided by the responses to laws—whether respondents chose more (Group 3) or less (Group 2) than middle option (scale 4). We believe that Group 3, Skeptical of laws, was more likely to think that current laws and policies are insufficient to protect against AI harms than Group 2, but we cannot exclude the possibility that they think laws and policies are generally not a good way to protect against AI harms. We call this segmentation "ELSI segments," which enables us to recognize the trend of public ELSI issues related to AI. AI researchers, AI engineers, and others could use this segmentation to uncover the tendencies the public is concerned about for ELSI related to AI.

The four groups were represented differently in the three countries. The majority of Japanese people were segmented into Group 2 (36%) or Group 3 (35%). This means that there were fewer Japanese people who had "extreme" positive (Group 1) or "extreme" negative opinions (Group 4) regarding the use of AI. Although the relative numbers of extreme responses were small, more people were segmented into Group 4 (20%) than Group 1 (9%). This suggests that fewer people had positive attitudes toward AI in Japan. While 65% of Japanese respondents agreed that the development of AI has been a good thing for society [1], they had concerns about ELSI related to AI. This may reflect a tendency for Japanese people to choose the middle option [32]. Respondents from the United States were evenly distributed within the four groups, making the United States the dominant country for "extreme" positive or "extreme" negative opinions. In a previous survey, 47% said that the development of AI has been a good development for society, while 44% said that AI has been bad for society [1]. These findings suggest that attitudes are likely to be divided in the United States. In Germany, many people were segmented into Group 2 (34%), which could mean that more Germans think "Policies and laws are sufficiently established," and this may reflect that AI regulations could be stricter in the European Union (e.g., [33]).

This study has at least four limitations. First, our segmentation was based on responses in Japan, the United States, and Germany. Segmentation could change if the choice of countries were different. Our analysis is also scenario specific. A different combination of scenarios could change the segmentation. Future studies should investigate whether there is any segmentation bias in each scenario. Second, we did not ask which specific ethics, tradition, and laws the respondents were concerned about. ethics, tradition, and laws are broad concepts. It remains unclear which specific things people had in mind when answering the questions. We found that the respondents' attitudes were divided, especially by laws. However, we cannot identify whether they thought that the legal aspects of research or potential legal systems that may stem from the research would be insufficient. More qualitative studies, such as interviews, are required for a deeper understanding. Third, respondents, such as those who responded to our survey, were necessarily limited to those who could use the Internet. Individual Internet use is developing quickly—in 2019, 92.7% of people in Japan, 89.4% in the United States, and 88.1% in Germany used the Internet [34], implying that a significant portion of the population can be covered by online surveys. Fourth, while we found that some respondents had concerns about

ethical, legal, and social aspects, it is unclear whether the expected benefits outweigh these concerns.

In conclusion, public ELSI concerns about AI are presented differently in Japan, the United States, and Germany. The majority of this study's respondents were classified as "Less skeptical of laws" or "Skeptical of laws" in each country, showing that the large dispersion of answers to the laws question was more significant than questions related to ethics and tradition. Age was a strong predictor of concern about AI, with older people having more issues with ELSI related to AI. Our results suggest that AI researchers and engineers need to discuss public concerns about ELSI related to AI with society in different contexts, at the country and global levels. ELSI segmentation is a useful tool for understanding public concerns about AI.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s43681-022-00207-y.

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## Declarations

**Conflict of interest** The authors declare no conflicts of interest.



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