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How Do People View Various Kinds of Smart City Services? Focus on the Acquisition of Personal Information

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Abstract: In smart city services, large volumes of personal information are generally captured, and urban development is based on that data. However, people do not always have accepting attitudes toward smart city services. The purpose of this study was to identify the expectations and anxieties that people have toward five typical services in smart cities (social credit, artificial intelligence (AI) cameras, health information, garbage collection, and automatic vehicles) by using mainly open-ended questions. An online survey was conducted with Japanese participants by presenting them with one of the five vignettes about the services described above. The results showed that the participants' expectations from each service were distinctly different between the vignettes. Anxieties about the leakage of personal information were found for the vignettes of social credit and health information. For the vignettes of AI cameras and garbage collection, anxieties that privacy would not be sufficiently ensured and that people would be involved in a surveillance society were noted. Additionally, the participants tended to exhibit lower accepting attitudes toward services considered to capture a large amount of personal information. We believe that our findings are meaningful to operators leading smart city projects and researchers in urban planning and psychology.

Keywords: smart city; anxieties about smart cities; expectations from smart cities

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1. Introduction

1.1. Background

In recent years, urban planning using artificial intelligence (AI) and big data has been spreading worldwide to solve diverse kinds of social issues [1,2], and attention to smart cities is rapidly growing around the world. In Europe, the United States, and China, the implementation of smart cities is progressing [3–9], but in Japan, the development has just begun. In Japan, Society 5.0—an initiative to create a human-centered society that balances economic development with the resolution of social issues through a system that highly integrates virtual interface and real spaces—is being promoted [10]. Especially, smart cities are attracting increasing attention as a place where Society 5.0 can be realized [11,12], and Japan's Cabinet Office has predicted that 100 smart cities will be created by 2025 [13]. Therefore, it is important to conduct various kinds of surveys on smart cities in Japan.

One of the most typical aspects of smart cities is the acquisition of personal information, such as citizens' income level, travel routes, health checkup results, lifestyle habits, and cell phone browsing history [14,15]. Examples include services to assign social credit scores to individuals based on their credit information, such as income and tax delinquency, and to apply preferential treatment based on these scores [16]; services to use AI cameras to collect information on pedestrian behavior for early detection of criminal activity and wandering elderly [17–19]; and services to manage citizens' health care based on the results of health checkups [20–22], are being planned and implemented. On the contrary, there

are services where the amount of acquired personal information seems to be relatively small. For example, services to install AI sensors in garbage collection stations to record the amount and type of garbage to improve the efficiency of garbage collection [23] and automatic public transportation [24,25] are being planned and implemented. As described above, the content and amount of captured personal information vary greatly depending on the purpose of each plan and scientific technology.

1.2. Problems

While these movements are gaining momentum, major problems remain, which need to be addressed. One of the issues is a social problem related to people's accepting attitudes toward smart city services. In general, when implementing new scientific technology in a particular region, conflicts of opinion are likely to arise between the local government or company leading the project and the citizens [26–28]. The protection of privacy is an important issue closely related to the implementation of smart cities [29], and people's cognition and emotion about captured personal information may strongly influence their attitudes toward smart city services. An example of a smart city that became a social issue due to strong opposition from citizens is the plan of Sidewalk Labs in Toronto, Canada [30]. The plan was to develop a wide waterfront area and capture personal data by installing sensors in many places throughout the city [31]. In the project, much captured personal information, such as the location of smartphones, would be commercialized [32]. The service was faced with strong opposition from citizens and became a social problem, which eventually led to its cancelation [33,34]. As in this example, inadequate accepting attitudes from citizens toward smart city services may hinder the implementation of such projects.

Then, in what cases will accepting attitudes toward smart city services decrease excessively? To find the answer to this problem and to foster accepting attitudes, previous studies referred to the technology acceptance model (TAM), which handles accepting attitudes toward scientific technology [35–38]. TAM suggests that the target technology's perceived ease of use and usefulness increase behavioral intention to use and positive attitudes toward the use, which lead to the actual use of the technology [35]. Studies have attempted to extend TAM and have shown that trust in city governments and business operators is one of the important factors. Specifically, the perceived ease of use and usefulness are increased by trust in technology [39], and such trust positively affects behavioral intention to use, mediated by reduced risk perception [40]. In addition, research has shown that various factors, such as perceived risk, justice, the necessity of technology, and benefit to the effort ratio, should be focused on to foster accepting attitudes toward various kinds of scientific technologies [28,41–43].

In implementing smart cities smoothly and in achieving the expected benefits, it is necessary to encourage citizens to develop adequate accepting attitudes toward the projects. However, previous studies have not comprehensively clarified people's specific expectations and anxieties directed toward the various kinds of smart city services. As mentioned above, there is a wide range of smart city services, and it is important to disentangle what spontaneous expectations and anxieties people have for the typical projects. In addition, studies reported that there are cultural differences in the accepting attitudes toward scientific technology [44–46], and it is meaningful to conduct this survey in Japan, where the implementation of smart cities is increasingly active.

1.3. Purpose

The purpose of this study was to investigate what expectations and anxieties people have about smart city services that differed greatly in the content and amount of captured personal information. The novelty of this study is that we conducted a survey with open-ended items and analyzed the data using text mining to determine what people expect from and are anxious about typical services in smart cities. In addition, examples of participants' specific responses would be of sufficient material value. This study provides knowledge that should be referred to by business operators and academic researchers specializing

in urban planning and psychology, who are aiming for the smooth implementation of smart cities by increasing accepting attitudes from citizens. In addition, by presenting an empirical research method, such as the one used in this study, it will be possible to conduct comparative research in other countries.

1.4. Overview

In this study, vignettes for five services that differed greatly in the content and amount of captured personal information were presented to the participants. While we used quantitative items to measure accepting attitudes toward each service, we also used open-ended questions to measure participants' specific expectations and anxieties. Therefore, we aimed to understand the expectations and anxieties expressed spontaneously by the participants, rather than those predetermined by academic researchers. We also identified where the participants' interests and concerns are directed, and then discussed the relationship with accepting attitudes.

2. Materials and Methods

2.1. Methodology

We conducted an online survey in June 2021 and asked participants what their expectations and anxieties are from the five typical services in smart cities, using open-ended items. Aside from general quantitative items, the use of open-ended items allows for the extraction of a wide range of cognition and emotion toward the subject [47,48]. The data obtained from open-ended items can also be analyzed through text mining to obtain an overview of the entire dataset [49]. Thus, open-ended questions can adequately address highly novel social phenomena that have yet to be conceptualized in psychological research [50]. Additionally, with the improvement of statistical software, researchers are now able to conduct text mining with relative ease [51].

In this study, we conducted a morphological analysis and referred to the term frequency-inverse document frequency (TF-IDF). The TF-IDF is the product of the term frequency of each word and the value obtained by taking the log of the total number of texts divided by the number of texts in which the word appears [52]. The higher the TF-IDF, the more relevant the word is in the text [53]. For this reason, the TF-IDF has been frequently used in information seeking and sentence summarization [54].

2.2. Participants

Participants were recruited using the crowdsourcing service CrowdWorks. A total of 1015 Japanese individuals (18–78 years old; 361 men and 654 women) participated. Participants were recruited from all over Japan without any restrictions on age, gender, or region of residence. The limitations of this sampling approach are discussed later. The mean age of participants was 39.33 years (SD = 10.40). This study was approved by the Ethics Committee of the authors' institution.

2.3. Vignettes

Each vignette was developed for five services that differed greatly in the content and amount of captured personal information. The vignettes were related to social credit, AI cameras, health information, garbage collection, and automatic vehicles, in the order of the amount of personal information considered to be captured. In addition, we confirmed through a supplemental survey that this assumption about the amount of captured personal information in each service was correct (see Open Science Framework; OSF, website in Supplementary Materials).

The social credit vignette depicted a service to disclose individuals' information on illegal activities and tax delinquency to financial institutions for use in lending decisions. The AI cameras vignette depicted a service to install AI cameras on streetlights to automatically identify the age and gender of pedestrians for the early detection of crimes. The health information vignette depicted a service to suggest preventive measures and to reduce

medical costs based on the results of personal health checkups. The garbage collection vignette depicted a service to use AI sensors to record the degree of garbage separation, to raise environmental awareness among citizens, and to reduce costs. The automatic vehicles vignette depicted a service to curb labor costs by automating buses and cabs. The content of each vignette was adapted from the actual or planned projects described above [14–25]. The full texts of the vignettes were posted on the OSF.

2.4. Items

Participants were asked open-ended questions about what they expected from and what they were anxious about the service. Specifically, we posed the following two questions: "How do you think the realization of this form of "smart city concept" will have a (positive/negative) impact on yourself and society as a whole? Please describe what you (expect from/are anxious about) this service in as much detail as possible." These were called an expectation item and an anxiety item, respectively. The response fields of the questions were wide enough, and there was no word limit.

As a quantitative indicator, we measured the degree of accepting attitudes toward smart city services. Specifically, the following items were used: "Would you like to live in such a smart city?" and "Do you favor municipalities that promote such a smart city project?" The participants responded using a six-point Likert scale ranging from "totally disagree" (1) to "very much agree," (6) and the mean of the two items was used as the score of accepting attitudes ($r = 0.83$, $p < 0.001$). The participants' demographic characteristics, including their age, gender, and nationality, were assessed.

2.5. Procedure and Analysis

The survey was conducted online. The participants read one of the randomly assigned vignettes. At the time, we asked the participants to read a short vignette about the smart city project that is currently being promoted worldwide. We did not set a time limit for reading the vignette but instructed the participants to move on to the next page when they fully understood the content. Participants then responded to the expectation item, the anxiety item, and items assessing accepting attitudes and demographics. Vignettes were always displayed at the top of the screen and were freely available for viewing while participants were answering each item. The average time to finish the survey was eight minutes and four seconds. The analysis was performed using the statistical software R (ver. 3.6.2) and RMeCab [54], a tool for text mining in R. The data and script of the analysis were posted on the OSF.

3. Results

3.1. Morphological Analysis

The number of participants reading each vignette was as follows: social credit ($n = 177$), AI cameras ($n = 230$), health information ($n = 198$), garbage collection ($n = 204$), and automatic vehicles ($n = 206$). Morphological analysis was conducted on the response data for the expectation and anxiety items by separating each word and counting the term frequency of each word. In this process, conjugated words, such as verbs and adjectives, were automatically corrected to their original forms. The total number of words used in response to the expectation item was as follows: social credit ($n = 6624$), AI cameras ($n = 7952$), health information ($n = 7489$), garbage collection ($n = 8049$), and automatic vehicles ($n = 7111$). The total number of words used in response to the anxiety item was as follows: social credit ($n = 6195$), AI cameras ($n = 7333$), health information ($n = 6227$), garbage collection ($n = 7315$), and automatic vehicles ($n = 6448$).

In this study, we focused on words that were not included in the original vignettes but appeared in many of the participants' responses. We called these "feature words." Feature words are words that should be paid special attention to in this study because participants spontaneously expressed their expectations and anxieties about the services using these words. Table 1 shows the typical feature words used in response to the expectation and anxiety items

along with the term frequency. Typical responses by the participants that included feature words were posted on the OSF. In addition, there were no remarkable differences between men and women in their response to expectation/anxiety items. The table with the term frequency of each feature word by participants' gender is posted on the OSF.

Table 1. Typical feature words used in response to the expectation and anxiety items and their term frequency.

Vignette	Social Credit	AI Cameras	Health Information	Garbage Collection	Automatic Vehicles
Expectation	procedure (64)	control (55)	burden (22)	problem (29)	accident (54)
	management (17)	involve (20)	life expectancy (21)	recycling (19)	aging (43)
	useful (13)	kidnapping (16)	insurance (10)	wasted (14)	movement (18)
Anxiety	leakage (41)	privacy (73)	leakage (39)	surveillance (37)	accident (59)
	management (30)	misuse (34)	privacy (16)	privacy (26)	employment (38)
	misuse (18)	data (16)	fraud (12)	throw away (15)	trouble (24)

The numbers in parentheses indicate the term frequency of each feature word.

3.2. Analysis Using the TF-IDFs of Expectation Items

To compare the characteristics of the responses to the expectation and anxiety items between vignettes, we calculated the TF-IDF of each feature word. The TF-IDFs of feature words used in response to the expectation item are listed in Table 2. For the expectation item, the TF-IDFs of the feature words in the specific vignette were all higher than those in the other four vignettes. For example, the TF-IDF of "management" in the social credit vignette was 22.47, which was higher than the values of the other four vignettes (1.32, 17.19, 5.29, and 0). In particular, "procedure" was shown to be a representative feature word in the social credit vignette, "control" in the AI cameras vignette, "life expectancy" in the health information vignette, "recycling" in the garbage collection vignette, and "accident" in the automatic vehicles vignette. As described above, the responses to the expectation item differed greatly among the vignettes.

Table 2. TF-IDF of each feature word (expectation item).

Feature Words	Social Credit	AI Cameras	Health Information	Garbage Collection	Automatic Vehicles
procedure	212.60	0	0	0	0
management	22.47	1.32	17.19	5.29	0
useful	17.19	1.32	0	5.29	13.22
control	11.61	127.71	0	0	0
involve	0	46.44	0	0	2.32
kidnapping	0	53.15	0	0	0
burden	3.00	2.00	22.00	11.00	4.00
life expectancy	0	0	69.76	0	0
insurance	11.61	0	23.22	0	0
problem	4.00	4.00	6.00	29.00	5.00
recycling	0	0	0	63.12	0
wasted	9.25	0	3.97	18.51	5.29
accident	0	59.06	0	8.68	93.80
aging	1.32	47.59	25.12	0	56.84
movement	0	8.68	0	1.74	31.27

For visualization purposes, TF-IDFs of 10 or more are highlighted in orange, and those of 25 or more are highlighted in red.

3.3. Analysis Using the TF-IDFs of Anxiety Items

The TF-IDFs of feature words used in response to the anxiety item are presented in Table 3. Responses to the anxiety item showed similar characteristics among the vignettes. For example, in the three vignettes of social credit, AI cameras, and health information, which are considered to capture a large amount of personal information, the TF-IDFs of "management," "misuse," and "data" were high, and anxieties about the management and misuse of personal information were highly evident. In particular, in the vignettes of social credit and health information, the TF-IDF of "leakage" was high, and the leakage of personal information was a particular anxiety. Contrarily, in the vignettes of AI cameras and garbage collection, the TF-IDFs of "privacy" and "surveillance" were high, and anxieties about privacy protection and descriptions of how each service might lead to a surveillance society were highly evident. As for the TF-IDFs of other feature words, "fraud" in the health information vignette, "throw away" in the garbage collection vignette, and "accident," "employment," and "trouble" in the automatic vehicles vignette were especially high.

Table 3. TF-IDF of each feature word (anxiety item).

Feature Words	Social Credit	AI Cameras	Health Information	Garbage Collection	Automatic Vehicles
leakage	54.20	10.58	51.56	6.61	0
management	30.00	27.00	37.00	9.00	1.00
misuse	23.79	44.95	30.40	6.61	0
privacy	14.54	96.50	21.15	34.37	0
data	13.22	21.15	13.22	7.93	0
surveillance	12.00	86.00	5.00	37.00	2.00
fraud	6.00	4.00	12.00	2.00	2.00
throw away	0	0	0	49.83	0
accident	0	3.47	0	5.21	102.48
employment	0	0	1.74	10.42	66.00
trouble	3.47	0	0	15.63	41.69

For visualization purposes, TF-IDFs of 10 or more are highlighted in light blue, and those of 25 or more are highlighted in dark blue.

3.4. Accepting Attitudes

The mean scores of accepting attitudes were 3.59 (SD = 0.97) in the social credit vignette, 3.69 (SD = 0.94) in the AI cameras vignette, 3.78 (SD = 0.94) in the health information vignette, 3.85 (SD = 0.95) in the garbage collection vignette, and 3.94 (SD = 0.92) in the automatic vehicles vignette. We conducted a one-way analysis of variance (ANOVA) with the vignette as the independent variable and accepting attitudes as the dependent variable, and the effect of the vignette was significant ($F(4, 1010) = 4.04$, $p = 0.003$, $\eta^2 = 0.02$). Multiple comparisons using the Bonferroni method showed that accepting attitudes toward the social credit vignette were lower than those of the garbage collection vignette ($t(1010) = 2.66$, $p = 0.05$) and the automatic vehicles vignette ($t(1010) = 3.61$, $p = 0.003$). In addition, accepting attitudes toward the AI cameras vignette were lower than that of the automatic vehicles vignette ($t(1010) = 2.76$, $p = 0.03$). In summary, the participants tended to exhibit lower accepting attitudes toward services that are considered to capture a larger amount of personal information.

4. Discussion

In this study, we focused on the acquisition of personal information, which is one of the typical features of smart city services [14,15], and presented one vignette of the five services that differed greatly in the content and the amount of captured personal information (social credit, AI cameras, health information, garbage collection, and automatic vehicles) to participants. Open-ended items were used to investigate what participants spontaneously expected from and were worried about in these services. As a result, an extensive range of responses was obtained, and while the responses to the expectation item

differed greatly among the vignettes, the responses to the anxiety item showed certain similar characteristics among the vignettes. In addition, the participants tended to exhibit lower accepting attitudes for services that were considered to capture a larger amount of personal information.

4.1. Expectations and Anxieties about the Smart City Projects

The participants had diverse expectations from each service. If business operators are unable to meet these expectations adequately, accepting attitudes by citizens may decline. The findings of this study, based on numerous open-ended responses, will be highly useful for business operators implementing smart cities in considering what will be appealing to citizens. For example, when implementing services similar to the social credit vignette, it would be effective to communicate to citizens that procedures at government offices will become easier. On the contrary, when implementing services similar to the AI cameras vignette, it will be effective to communicate to citizens that the project will be a deterrent to crime.

At the same time, it is also clear that people have diverse anxieties about smart city services. In the social credit, AI cameras, and health information vignettes, where a larger amount of personal information is considered to be captured, anxieties about the management and misuse of personal information were highly reported. In particular, anxieties about the leakage of personal information stood out in the vignettes of social credit and health information. The personal information obtained in these services includes information on illegal activities, tax delinquency, and the results of health checkups, which is known only to a limited number of people, such as the individual and their family. Therefore, it is thought that there was high anxiety about the leakage of such confidential personal information to other people.

In the AI cameras vignette, there were notable anxieties that privacy would not be sufficiently ensured and that participants would be involved in a surveillance society. The personal information collected in this service includes people's age, gender, and travel routes. This information would be less confidential than the personal information obtained in the vignettes of social credit and health information (age and gender are already known to many acquaintances, and most people are unlikely to want to keep their travel routes secret from others). However, if such personal information is constantly being obtained daily, it would be uncomfortable for people as they would feel as though they are constantly being monitored. Therefore, many anxieties related to privacy and a surveillance society were evident in the responses to the AI cameras vignette. In the garbage collection vignette, where the amount of captured personal information is considered to be relatively small, there were anxieties about privacy-related issues and surveillance society. This may be because many participants believed that not only the achievement of garbage segregation, but also the detailed garbage contents of who threw what away would be obtained by the service. This suggests that it is necessary for business operators leading any kind of service, not only those similar to the garbage collection vignette, to clearly communicate to citizens what kind of and to what extent personal information will be obtained.

As for anxieties about the health information vignette, there were several statements, such as "fraud could be committed by taking advantage of the fact that a person is sick". A possible reason behind this tendency is the rampant health fraud, in which companies portray the excessive effects in health-conscious products as if the effects were real [55]. Such health fraud scams are highly problematic because they promote food faddism, which is the overestimation of and belief in the impact of food on health and disease [56]. In smart city services, if there is an anxiety that personal information about one's health will be used for fraud, it will be difficult to instill sufficiently accepting attitudes in citizens. Therefore, it is suggested that when acquiring individuals' health information in smart city services, business operators should specifically aim to dispel anxieties about fraud.

4.2. Limitations

There are three major limitations to this study. First, we could not determine the extent to which participants perceived the services depicted in the vignettes as familiar to themselves. In the expectation and anxiety items, we asked about the impact on participants and society at large. However, it was not possible to measure whether participants specifically envisioned the case where each service is implemented in the municipality where they live. This is a problem that is generally seen in studies using vignettes, and it is therefore necessary to conduct follow-up assessments with different variations of vignettes and more specific methods of assuming situations. Second, we focused on feature words (words that were not included in the original vignettes but appeared in many of the participants' responses) and did not examine the details of the words included in the vignettes. Since all the vignettes in this study were limited to descriptions of the specific contents of each service, we believe that the feature words that appear when participants spontaneously verbalize their feelings are important. However, it may be possible to extract a wide range of cognition and emotion from the participants by examining the important words in the vignettes. Although beyond the scope of this study, it will be meaningful to add a detailed analysis by focusing on words other than the feature words. Third, all participants in this study were of Japanese ethnicity, and we could not examine the effect of factors such as the location of each participant. Some previous studies have suggested that cultural differences in accepting attitudes toward scientific technology are significant [43–45]. In addition, although the participants in this study are thought to live in a wide range of regions in Japan, we cannot deny the possibility that a vast number of participants live in urban areas. Therefore, future research should consider the impact of cultural differences and the location of the participants.

5. Conclusions

Despite these limitations, we believe that this study has practical value in describing people's expectations and anxieties about typical smart city services (social credit, AI cameras, health information, garbage collection, and automatic vehicles). We also compared the responses to each service and organized the characteristics of the expectations and anxieties directed toward each service. In some cases, such as the plan in Toronto [30–34], strong opposition from the public has become a social problem. Therefore, it will be necessary to continue to examine people's cognition and emotion toward smart city services. The findings of this study will contribute to research to identify the attitudes that people have toward smart city services. In addition, we believe that our findings will be useful for business operators aiming for the smooth implementation of smart cities, as well as for researchers specializing in urban planning and psychology.

Supplementary Materials: Supplementary materials are available online at OSF (https://osf.io/qn9jv/, accessed on 26 August 2021).

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are openly available in the OSF (https://osf.io/qn9jv/, accessed on 26 August 2021).

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