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Dashcam Witness: Video Sharing Motives and Privacy Concerns Across Different Nations

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ABSTRACT Vehicle dashboard cameras or dashcams, among other smart vehicle technologies, are increasingly attracting interest across the globe. Furthermore, dashcam videos as objective witnesses are often shared to resolve various traffic incidents. In this work, we aim to understand cross-national differences in motives and privacy concerns of dashcam video-sharing, which are closely related to the factors that vary across countries, such as cultural values, traffic regulation, driving environments, and privacy perception. Toward this goal, we conduct a cross-national survey study with three countries with high dashcam adoption rates, i.e., China, Korea, and Russia. The survey results from these countries consistently revealed two major motives for sharing dashcam data: (1) reciprocal altruism and social justice, and (2) monetary reward. Respondents from all three countries felt more strongly towards reciprocal altruism and social justice and less towards monetary rewards. Regarding privacy concerns, however, the surveys presented discrepancies among these countries, indicating stronger cross-national influences on sharing concerns than on sharing motives. Cross-national differences in privacy concerns and their relationship with motives were nuanced and context-dependent.

INDEX TERMS Smart vehicles, autonomous vehicles, dashcam videos, user motivation, privacy concerns, video sharing, cross-national study.

I. INTRODUCTION

Vehicle dashboard cameras (i.e., dashcams) enable high-quality continuous recording of external views that provide evidence in case of unexpected traffic-related accidents and incidents. Furthermore, vehicles with semi-autonomous driving can even support more advanced surveillance modes with real-time sensing and recognition as in Tesla's recent software updates [1]. The demand for dashcams is expected to increase substantially around the world, where the dashcams market was valued at US $1.53 billion in 2014, and is expected to reach US $5.54 billion by 2022 [2]. The Asia Pacific region is predicted to see the fastest growth, where China represents the largest market worldwide [3] and the dashcam adoption rate has already exceeded 60% in Korea [4]. In China and Korea, public transportation and commercial vehicles are even required to install dashcams to assist in identifying the causes of accidents [5]. As for Russia and Europe, an estimated one million people across Russia have installed dashcams in their cars [6], and 39% of United Kingdom drivers are considering installing dashcams, with 71% believing that widespread dashcam usage would help reduce fraudulent car insurance claims [7].

Dashcams have gained massive popularity, especially in China, Korea, and Russia, possibly due to traffic safety and insurance reasons. According to statistics in 2013 [8], the estimated road traffic deaths were 18.8, 12.0, and 18.9 per 100,000 of the population for China, Korea, and Russia, respectively. Compared to developed western countries, such as the United States (10.6), Canada (6.0), or the United Kingdom (2.9), traffic safety is relatively worse in the three countries. Not only are dashcam adoption rates high in China, Korea, and Russia, online and offline sharing of various events captured by dashcams are becoming increasingly prevalent as well. Starting from the famous footage capturing the 2013 Chelyabinsk meteor by dashcam that went viral online, thousands of dashcam videos showing various accidents and incidents on roads, such as massive crashes or

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insurance fraud attempts by other drivers and pedestrians, are shared through diverse channels, from global social network sites such as *YouTube*, *Facebook* and *Reddit* to popular local websites such as *Bobaedream* in Korea, *Youku* in China, and *Vireg* in Russia. Beyond public posting, citizens share dashcam videos (known as *dashcam witnesses*) to resolve disputes in traffic incidents and accidents because dashcam videos can be used as objective evidence [9]. For this reason, they often post on local online forums and portal websites asking to share particular dashcam scenes.

Dashcams as *continuous mobile sensing and recording* devices can capture diverse scenes due to vehicle mobility and have wide *spatial-temporal coverage with a variety of sensor data annotation* (e.g., location and driving events). Furthermore, recent dashcams even feature advanced driver-assistance (e.g., object detection and recognition) and wireless networking (e.g., WiFi and 4/5G). As intelligent mobile sensing platforms, dashcams have a great potential to host a broad range of crowdsensing services such as context-aware video sharing [10], accessibility mapping [11], [12], and vehicular urban sensing [13]. However, data sharing poses privacy risks because of its wide range of annotated sensor data, and spatial-temporal coverage, which may negatively influence sharing motives as reported in existing online services [14], [15].

Dashcam sharing behaviors are closely related to many factors that vary across different nations, such as cultural values, traffic regulations, driving environments, and privacy perception. Prior studies also highlighted the importance of contextual factors in sharing motives and privacy concerns [16]–[19]. As national differences necessitate diversity in design principles to support effective interactions [20], understanding and analyzing national differences in dashcam video sharing are vital to properly design online services that promote dashcam video sharing. The importance of culture analysis is further substantiated by the growing literature of exploring various cultural perspectives in the human-computer interaction (HCI) field, such as information sharing patterns [21]–[23] and privacy concern differences [24], [25]. To the best of our knowledge, so far there has been a significant lack of prior studies on large-scale cross-national surveys on information sharing practices with *mobile sensing and recording devices*.

This paper investigates the key motives and privacy concerns of dashcam video sharing for traffic-related accidents across China, Korea, and Russia in regard to various socio-cultural characteristics. Our selection of three countries was due to the fact that these countries had high dashcam adoption rates, covering the majority of dashcam users in the world. Considering real dashcam users is critical for studying stabilized views on privacy invasive technologies, because associated privacy concerns often transition from pessimistic levels to optimistic levels over time [26]. Despite their geographical proximity, these countries have various contextual diversity in terms of cultural values, socio-political backgrounds, traffic regulation, and driving environments.

These prior studies and the lack of large-scale multinational studies motivate us to answer the following research questions:

- RQ1) Do the sharing motives of dashcam videos differ across three countries? If so, which motivational factors are significant in dashcam video sharing, and how are they perceived differently by users from three countries?
- RQ2) What are the major concerns that may hinder users from sharing dashcam videos and are there any differences across three countries?
- RQ3) How are differences in levels of concern about privacy reflected in dashcam sharing motives across three countries? How are different nations related to any of these differences among privacy groups?

Our study builds upon the prior exploratory study that identified the key motives and concerns of dashcam video sharing in Korea [27]. As an extension to this prior study, we perform a survey study on the motives and concerns of dashcam video sharing across different nations (Korea: $n = 373$, China: $n = 317$, Russia: $n = 400$). Various statistical analysis techniques are applied to gain insight into motives and concerns regarding dashcam sharing for each country, as well as the differences among countries.

Our results indicated two main motives for dashcam video sharing—Factor 1: reciprocal altruism and social justice, and Factor 2: monetary reward. Respondents from all three countries expressed stronger motivation for reciprocal altruism and social justice than for monetary rewards. Similarly, high levels of Factor 1 scores were present across China, Korea, and Russia, while respondents in Russia had significantly lower Factor 2 scores compared to respondents in Korea or China. Furthermore, the level of privacy concern related to dashcam video sharing was compared using three categorized privacy themes: privacy sensitivity of recorded data, data management practices, and trust level differences across requester entities. There was more discrepancy among the three countries regarding privacy concerns, which indicated stronger cross-national influences on sharing concerns than on sharing motives. We also found that sharing motives varied across groups with different levels of privacy concerns, and the groups with the strongest privacy concerns had much high monetary motivation than the other groups. As alluded in the conflicting findings on the relationship between cultural dimensions and privacy concerns [24], [28], there was a lack of patterns related to the cultural dimensions in our results, and cross-national differences in privacy concerns and their relationship with motives are rather nuanced and context-dependent, possibly due to diverse socio-cultural and political backgrounds, traffic safety and legal situations, and technology acceptance/adoption levels (due to the diversity of collected data types such as video, sound, and location with dashcams). Our findings provide insights to successfully design an online dashcam sharing service that can accommodate dashcam users with various socio-cultural backgrounds.

II. BACKGROUND AND RELATED WORK

Dashcams are relatively new recording devices, and though there is limited research directly related to dashcam video sharing context, increased research is being conducted related to vehicle-based sensor data [29], [30] and dashcam technology, such as anticipating accidents [31] or moving object detection algorithms in dashcam videos [32]. In this section, we briefly state the importance of vehicular sensing and recording, and its applications and then review prior studies regarding national differences in online information sharing, information privacy concerns, and traffic safety perceptions to discuss similarities and differences in terms of dashcam video sharing motives and concerns.

A. VEHICULAR SENSING & RECORDING AND VIDEO DATA SHARING

A dashcam is a novel technology that supports advanced sensing and video recording in vehicles (including basic event data recording, or EDR). Recent dashcams even support advanced driver-assistance systems (ADAS) features such as lane departure warning, obstacle detection, and wireless communications (e.g., WiFi and Bluetooth connection to smartphones, or cellular communications like 4G and 5G), which help to provide context-aware video data recording [33]. Autonomous vehicles can easily support advanced sensing and recording as evidenced by Telsa's recent software updates (V9) for dashcam support [1]. Video recording has been widely used for property monitoring (e.g., smart security and surveillance cameras for home) and lifelogging purposes (e.g., wearable cameras). When compared with such devices, dashcams as *continuous mobile sensing and recording devices* capture diverse scenes due to vehicle mobility (e.g., nearby cars and pedestrians, residents, and people in parking lots), and thus have much greater *spatial-temporal coverage with a variety of sensor data annotation* (e.g., location, driving events).

Although vehicular mobility is mostly constrained by public roads, captured videos may include privacy intrusive data in various personal spaces (e.g., drivers' embarrassing behaviors, or behaviors inside garage). Dashcams are not only used for personal purposes, but also commercial purposes such as fleet management and public safety. In Korea, as of September 2019, dashcam installments have become mandatory for public safety in major transport modes (i.e., buses and taxis) (Transportation Service Law, Act 27). Advanced ADAS and EDR features will become mandatory in the EU (although videos are not included) in 2022 [34]. Dashcam-like devices are even used for bicycles, motor cycles, and powered wheelchairs. Currently vehicle dashcams are primarily used for resolving accidents/incidents and social sharing (through Youtube and Reddit). We expect that advanced sensing and networking features in dashcams (or in autonomous vehicles) will help to design applied sensing services, ranging from road mapping and accessibility profiling [11], [12] to proactive urban monitoring and citizen science projects [10], [13], [35]. However, prior HCI studies on sensing and video recording are mostly focused on smart home and lifelogging contexts [36], [37]. The coverage and contexts of dashcam data are very different from existing data sources. Prior studies showed that sharing motives and privacy concerns are highly contextualized [16]–[19], and thus, dashcam video sharing require further investigation. This knowledge would be useful for exploring design spaces of novel dashcam-based crowdsensing services.

B. INFORMATION SHARING MOTIVES ACROSS DIFFERENT NATIONS

Researchers have studied motivations for sharing various types of information such as knowledge [38], photos [39], [40], location data [41], and life-log data [42]. However, less attention has been paid to nations differences in sharing motives. Yang *et al.* [21] investigated cultural differences in social question asking behaviors across four countries (i.e., United States, United Kingdom, China, and India) using a survey. They found that culture was a more prominent factor compared to other demographic factors (i.e., gender and age) in explaining differences of question types and question topics in social media-based Q&A across users of the four countries. Altruism and feeling good were the most common motivations for all countries, where Asians, especially Chinese, were motivated by the expectation of social reciprocity. Ardichvili *et al.* [22] showed that cultural preferences of employees should be considered in knowledge management systems. They examined knowledge sharing patterns in an online environment by interviewing employees in Russia, China, Brazil, and the United States. They found that Chinese are more likely to shy away from contributing to online community discussions because of their worries about face, modesty, and the lack of language proficiency, than their Russian counterparts. Patel *et al.* [23] investigated the effects of culture on technology use, focusing on mobile photo sharing in the US and Korea. They found that the cultural background of a user largely affects the way technology is used (e.g., the number of photographs taken). Though our work considers dashcams mainly involving video data, some level of cultural differences found in the photo sharing context could be expected to appear in video sharing as well. Prior work also examined the effect of culture on interpersonal trust and online information sharing: in their public goods game experiment, Liu *et al.* [43] found that interdependent people in Asia had higher interpersonal trust and information sharing than independent people in Europe (Chinese vs. German). As shown later, we expect that the motives and concerns of dashcam video sharing are related to the trust with whom the data will be shared.

C. INFORMATION PRIVACY CONCERNS ACROSS DIFFERENT NATIONS

Our work considers privacy concerns in the context of dashcam video sharing. Recent privacy studies investigated users' privacy concerns on various video recording devices,

including mobile and wearable cameras [36], [37]. Researchers found that privacy concerns are highly contextualized (e.g., people, objects, activities, and locations) [16]–[19] and people generally lack the tools, motivation, power, or knowledge to control and access the recording environments [18]. In the case of mobile video sharing with wearable cameras, wearers were willing to share images if there were any good reasons to do so, as long as contextualized privacy concerns were not present [44]. Our work extends prior studies by studying privacy concerns related to dashcam video sharing across three different countries. It has been shown that various dimensions affect individuals' privacy and that culture—which could be considered at many levels, such as socio-cultural, political, or the individual level—can explain differences in privacy attitudes [45], [46]. Our research is based on vehicle dashcams, which have mobility and wider coverage in the real world and supports the generation of various data types (e.g., video, sound, and location), and hence motives and concerns will be different from existing research [29], [47].

As the most accepted cultural framework, the Hofstede's four indices of national culture [48] (individualism, power distance, uncertainty avoidance, and masculinity) have been widely used to study cross-cultural differences in online privacy concerns. China, Korea, and Russia are considered collectivist societies where groups are valued over individuals and social reciprocity is important. Despite similarities, power distance score (i.e., the tendency of accepting inequality of power and wealth) is relatively high in China (80) and Russia (93) as opposed to Korea (60). Here, the score ranges from 1 for the lowest to 100 for the highest. Prior studies showed mixed results on the relationship between cultural dimensions and privacy concerns in information sharing [49]–[52]. For example, the individualism index (indicating how much people emphasize individual decision making and achievements) was positively related [49], [52] and negatively related [50]; e.g., a positive influence means that people from highly individualistic cultures are more worried about privacy risks. The power distance index (representing how much people are willing to accept inequality of power and wealth) was positively related [49] and negatively related [50]–[52]; e.g., a negative influence means that individuals in high power distance cultures may tolerate higher levels of power inequality in personal information access related to privacy concerns.

Beyond such cultural values, prior studies also reported that cross-national differences in privacy concerns are nuanced and context-dependent (e.g., interaction modality and motive differences). For example, Zhao *et al.* [24] studied how cultures affect communication mode (i.e., face-to-face vs. online) and characteristics of the relationship (i.e., closeness and openness) in online communities by comparing China versus the United States through a scenario-based survey. They found that United States respondents would disclose more than Chinese respondents when face-to-face, but both groups had similar levels of disclosure online. Tsoi and Chen [25] found that French users preferred sharing general contents such as news and events whereas Hong Kong users often posted personal content such as hobbies and personal life. Thus, it is important to consider various contextual factors for data sharing such as trust and traffic safety perception across different nations.

Making information sharing decisions are closely related to the concept of the *privacy calculus* [53], and researchers found that cultures influence privacy calculus behaviors [28]. Privacy calculus explains that when making information sharing (or disclosure) decisions, users perform a simple cost-benefit analysis, and information sharing is likely to happen if perceived benefits (or use motives) outweigh the perceived costs of privacy risks. Prior studies identified privacy calculus behaviors in diverse domains. For example, e-commerce users share their personal information to the online sites for the benefits/motives of monetary and time-saving, self-enhancement, altruism, pleasure, and social adjustment [54]. In social media, the extent of information sharing (e.g., in the Facebook profile page) depends on users' perceived privacy risks, and those who have strong motives for relationship maintenance and enjoyment tended to disclose more information [55], [56]. Trepte *et al.* [28] showed that cultures have significant influences on cost-benefit analyses: people from individualistic cultures had lower social motives compared to those from collective cultures, and people from high uncertainty avoidance cultures considered that privacy risks were important in cost-benefit analyses.

D. TRAFFIC SAFETY AND RISK PERCEPTION ACROSS DIFFERENT NATIONS

As dashcams are used mainly on the road in a driving environment, it is important to understand unique backgrounds regarding traffic safety and risk perception across multiple cultures. It is well known that there are substantial differences between countries in driving styles and skills [57]. Lund and Rundmo [58] studied cultural differences in perception and attitudes towards traffic safety and risk in the Norwegian and the Ghanaian cultures and observed major differences. The authors focused on making a comparison between developing counties (i.e., Ghana) and developed countries (i.e., Norway), arguing that people would likely have different perception towards safety or risk depending on their cultural background. The results showed that Ghanaians perceived a greater probability of being involved in traffic accidents and also judged the consequences to be more severe than Norwegians, as supported by the more hazardous traffic environment in Ghana. Wang *et al.* [59] studied not only the cultural differences in environmental factors (i.e., traffic safety cultures) but also how people use related technology tools (i.e., advisory traffic information systems). They considered multiple scenarios that drivers could encounter while driving and made comparisons between Chinese and Swedish drivers using various performance measurements, such as wheel steering or break usage, with or without their designed advisory traffic information systems (ATIS). Not only do traffic

TABLE 1. Survey questionnaire for each subscale.

Subscales	Motivation
Altruism 1	I share my dashcam footage because those who are in need of videos will use my contribution.
Altruism 2	It is important to help others by providing dashcam footage without expecting anything in return.
Altruism 3	I expect dashcam users to actively share their dashcam footage without expecting anything in return.
Reciprocity 1	I expect other people to help me, so it is only fair for me to help them by sharing my dashcam footage.
Reciprocity 2	If I receive dashcam footage from other people, I should share my footages with others in return.
Reciprocity 3	I will actively share my dashcam footage to help others, if I was helped by others' dashcam footage.
Social justice 1	I share my dashcam footage to achieve social justice.
Social justice 2	If sharing my dashcam footage can resolve an unjust accusation or a wrong treatment, I will actively help victims.
Social justice 3	Sharing dashcam footage helps to achieve justice in society.
Monetary reward 1	I need financial benefits to share my dashcam footage.
Monetary reward 2	I will share dashcam footage to make financial profits.
Monetary reward 3	I will make financial profits by sharing dashcam footage.

safety cultures (TSC) strongly affect how drivers respond to a situation, but also drivers from China and Sweden respond and utilize ATIS differently.

III. METHODOLOGY

This cross-national study builds upon the prior study [27] which identified major motivations and themes of privacy concerns behind dashcam video sharing from the online survey responses in Korea by categorizing free-text input answers with affinity diagramming. As an extension, we comparatively analyzed the survey results from China, Korea, and Russia to understand similarities and differences of sharing motives and concerns.

A. SURVEY CONTENT

Basic demographics (i.e., gender and age), driving, and dashcam usage experiences (i.e., number of years of driving experience, dashcam usage period, and dashcam specification information such as the number of channels, price, and GPS function) were first collected before going into the motives and concerns questionnaire.

The motives questionnaire comprised 12 items in the 7-point Likert scale, and each sub-scale consisted of 3 items (see Table 1). Sub-scales included in the motives questionnaire were modified by referring to existing scales. We modified three altruism items from Budhathoki and Haythornthwaite [60]; e.g., "It is important to help others by providing dashcam footage without expecting anything in return." We modified three reciprocity items from Cho *et al.* [61]: e.g., "I expect other people to help me, so it is only fair for me to help them by sharing my dashcam footage." We adapted one social justice item from Dean's work [62] and developed two other items: e.g., "Sharing dashcam footage helps to achieve justice in society." Regarding monetary rewards, we adapted three items from Budhathoki and Haythornthwaite [60]; e.g., "I will make financial profits by sharing dashcam footage." All these sub-scales had high consistency with their Cronbach's alpha value greater than.80.

Similar to sharing motives, three sharing concern themes were extracted based on the preliminary survey insights [27]. The first theme involved six items regarding privacy sensitivity of dashcam video (i.e., recorded audio, driving routes, video content with traffic violation, video content without traffic violation, bystander privacy, and passenger identities), the second theme involved five items on data management (i.e., misuse of shared video and GPS information, identity exposure, retaliation and non-disposal of shared data), and the last theme involved three items on data management trustworthiness of different parties (i.e., police, insurance company, and individuals involved in the accident). All items were formed into sentence structures; for instance for recorded audio concern, "I am concerned about recorded audio in the vehicle," then respondents answered in 7-point Likert scale to express their level of concern. A list of concern items within each theme can be found in Table 3.

B. TRANSLATION

In multilingual survey projects, translation procedures play a central and important role. Harkness [63] suggested team translation procedures as an effective approach. Another common method is translation and back-translation, where translation in the target language is re- (or back-) translated into the source language (e.g., [24]) or do-it-yourself ad hoc translation where someone who can speak and write two languages performs the translation task (e.g., [23]). Native

Korean, Chinese and Russian speakers who are all comfortable communicating in English as well participated in the translation process in our research. As our original Korean survey refers to the questionnaire from the prior study [27], the entire survey was translated into English first.

For the survey conducted in China, a native Chinese speaker who is fluent in English and proficient in Korean translated the survey into Chinese from the English and Korean versions. Two additional native Chinese speakers reviewed the translated Chinese survey version. In this case, back-translation was not used because three native speakers reviewed and discussed the results. For the Russian survey, a native Russian speaker who is fluent in English but limited in Korean created the initial translation version, then a back-translation process to English was performed. Afterward, an additional native Russian reviewed the survey.

C. RECRUITMENT AND DEMOGRAPHICS

The recruitment for the survey in Korea was accomplished through direct online postings on various community websites [27]. For surveys in China and Russia, we hired professional survey providers who maintain participant pools. Our survey participation was limited to those who have a car equipped with a dashcam—to check this, we asked the participants to report vehicle/dashcam models and years of use. This restriction was chosen because responses from real dashcam users would help us to characterize an emerging phenomenon of video sharing involving various types of a party (e.g., police, an insurance company, and an accident involved party). Actual sharing experiences were not required due to the difficulties of recruiting those users who actually share the dashcam videos for traffic-related reasons.

In China, the responses were collected by a Chinese survey provider, *Sojump* .[1] The screening survey (e.g., driver's license, car model, commuting method) was delivered to a total of 12,116 candidates; then, qualified users from this pool were selected, resulting in 317 valid responses. The total price of conducting the survey was approximately US $555. In Russia, the survey was distributed through an online survey provider, *Anketolog* .[2] The company maintains a database of 43,266 respondents from Russia and other former country members of the USSR who actually participated in the survey and were compensated. To screen for appropriate respondents for our survey, three conditional criteria were used; the respondent must be Russian, a car owner, and a dashcam owner. The total qualified number of respondents was 400, and each was paid approximately US $0.5 for participation with a total price for conducting the survey of approximately US $434. Although the gender distribution was skewed towards males in Korea (8.0% female and 92.0% male), compared to China (47.6% female and 52.4% male) or Russia (53.5% female and 46.5% male), there was no indication of significant differences in the major factor scores of motives and concerns across the three countries, except the Factor 2 of motive scores (i.e., Monetary reward) in Russia (male: 2.27 vs. female: 1.91).

[1]http://www.sojump.com
[2]http://anketolog.com

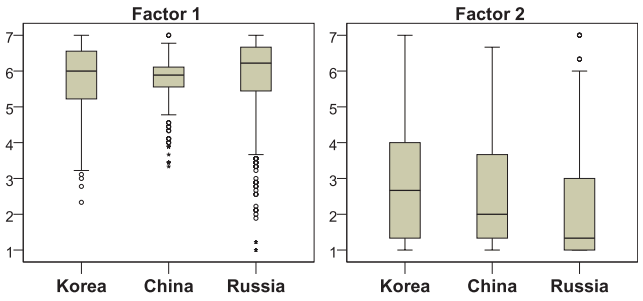

FIGURE 1. Boxplots of mean motive scores for Factor 1 and Factor 2 across countries.

IV. SHARING MOTIVES

In this section, we answer the first set of research questions: *Do the sharing motives of dashcam videos differ across three countries? If so, which motivational factors are significant in dashcam video sharing, and how are they perceived differently by users from three countries?* To answer these questions, we conducted a factor analysis to discover underlying factors in each country by clustering items, using the survey results of the 12 sharing motive items, which referred to one of four subscales—altruism, reciprocity, social justice, and monetary reward. Underlying assumptions were accessed prior to analysis to make certain of the suitability of factor analysis. The overall Kaiser-Meyer-Olkin (KMO) measures obtained were 0.878, 0.866, and 0.907 for Korea, China, and Russia, respectively, and individual KMO measures greater than 0.6 confirmed the adequacy of sampling. Bartlett's test of sphericity was also statistically significant (p <.0005), indicating that the data was likely factorizable.

For China, initial examination of the correlation matrix revealed that the subscale Reciprocity 1 does not have any correlations greater than 0.3 with any other variables, which suggests that this variable may not be suitable for factor analysis. The Reciprocity 1 had a low factor loading value of 0.301, and therefore it was removed from further analysis. Factor analysis with Varimax orthogonal rotation revealed two factors for all three countries that had eigenvalues greater than one. Mean and standard deviation of motives scores for Korea, China, and Russia are shown in Table 2.

Factor 1: reciprocal altruism and social justice values were significantly high across all three countries, suggesting that the reciprocal altruism and social justice motive was the prominent factor for all three countries. For mean Factor 1 scores, visual inspection of boxplots indicated several outliers, especially in lower value ranges (see Figure 1), and the Shapiro-Wilk's test also indicated that data is not normally distributed (p <.0005 for all three countries). The distribution of Factor 1 scores was significantly different among countries as confirmed by a Kruskal-Wallis test: $\chi^2(2) = 27.755$, p <.0005. Subsequent post hoc pairwise comparison with

TABLE 2. Mean and standard deviation motive scores across three countries.

Motives	Korea		China		Russia	
	Mean	SD	Mean	SD	Mean	SD
Factor 1	5.82	0.92	5.75	0.62	5.83	1.23
Altruism 1	5.81	1.23	6.02	1.03	6.23	1.28
Altruism 2	5.66	1.36	5.95	1.10	5.97	1.49
Altruism 3	5.31	1.57	5.88	1.12	6.03	1.50
Reciprocity 1	5.46	1.50	4.24	1.91	5.83	1.58
Reciprocity 2	5.86	1.30	5.70	1.11	5.11	1.86
Reciprocity 3	6.27	0.99	5.90	1.09	5.46	1.71
Social justice 1	5.75	1.29	6.00	1.05	6.01	1.47
Social justice 2	6.48	0.81	6.17	0.98	6.04	1.46
Social justice 3	5.78	1.30	5.89	1.07	5.83	1.55
Factor 2	2.78	1.50	2.57	1.55	2.08	1.35
Monetary reward 1	2.95	1.66	2.47	1.68	2.16	1.57
Monetary reward 2	2.77	1.69	2.62	1.72	2.14	1.56
Monetary reward 3	2.64	1.60	2.64	1.77	1.94	1.44

Bonferroni correction showed statistically significant differences in factor score distributions among all three countries, Korea (mean rank = 521.23) and China (mean rank = 478.38) with $p = .027$, Russia (mean rank = 602.68) and Korea with $p = .020$, and China and Russia with $p < .0005$.

Factor 2: monetary reward values were significantly lower across all three countries, especially in Russia, indicating that respondents are marginally motivated by monetary reward for dashcam video sharing. Mean Factor 2 scores were skewed towards the lower values (positively skewed) as opposed to Factor 1 (negatively skewed) along with some outliers towards maximum values in Russia (see Figure 1). The distribution of Factor 2 of Russian (mean rank = 453.46) scores was significantly different from those of Korea (mean rank = 616. 37) and China (mean rank = 578.25), which was confirmed by a Kruskal-Wallis test: $\chi^2(2) = 58.350$, $p < .0005$. Post hoc pairwise comparisons with Bonferroni correction were statistically significant with $p < .0005$ for both the distribution difference of Russia and China and the distribution difference of Russia and Korea, while the difference between Korea and China was not significant with $p = .322$.

V. SHARING PRIVACY CONCERNS

In this section, we answer the second set of research questions: *What are the major concerns that may hinder users from sharing dashcam videos and are there any differences across three countries?* Sharing concern level for each country is presented in Table 3, and the comparisons were made across countries for each concern theme.

A. PRIVACY SENSITIVITY CONCERNS

The mean privacy sensitivity score of Russia (3.78) was relatively low compared to those of Korea (4.27) and China (4.28), as determined by a Kruskal-Wallis test: $\chi^2(2) = 31.794$, $p < .0005$. Post hoc pairwise comparisons with Bonferroni correction confirmed statistically significant differences in privacy sensitivity scores between Russia and Korea ($z = 4.627$, $p < .0005$) and Russia and China ($z = 4.995$, $p < .0005$), but not between China and Korea ($z = -0.557$, $p = .578$).

The prominent item among privacy sensitivity concerns was different in each country; Korean respondents were most concerned about recorded audio, Chinese respondents were most concerned about bystander privacy, and Russian respondents were most concerned about passenger identities. Concern towards recorded audio (mean = 4.97) appeared rather strongly from respondents in Korea, as it was significantly higher than either the second or third concern items, video content with traffic violation ($z = 3.478$, $p = .002$) and bystander privacy ($z = 3.387$, $p = .002$) by post hoc pairwise comparison following the Friedman test, respectively. As for China and Russia, recorded audio concern level placed around the overall privacy sensitivity concern mean values, being fourth and third items, respectively, among six privacy sensitivity items.

Chinese respondents did not express particular concern towards a single item, but rather had similar levels of concern across bystander privacy (4.44), video content with traffic violation (4.42), passenger identities (4.41), and recorded audio (4.37)—those four were higher than overall privacy sensitivity concern (4.28) and each was significantly higher than fifth-ranked item, driving routes (4.14), as confirmed by post hoc analyses with Bonferroni correction following the Friedman test.

As indicated by lower overall privacy sensitivity score, respondents in Russia did not express particularly dominating concerns other than passenger identities. Recorded audio, video content without traffic violation, bystander privacy, and driving routes fell below an average privacy sensitivity score of 3.78, while video content with traffic violation had an average score of 4.00. These five items were statistically lower than the passenger identities item at a significance level 0.01 according to the post hoc pairwise comparison with a Bonferroni correction.

One common observation across the three countries was the higher level of concern towards video content with traffic violation than that towards video content without traffic violation. Differences between the two items were statically significant in all three countries, as revealed by Wilcoxon signed-rank test: $z = 9.496$, $p < .0005$ in Korea, $z = 5.289$, $p < .0005$ in China, and $z = 2.806$, $p = .005$ in Russia, indicating that whether a dashcam owner's traffic violation was included in the shared footage is a significant factor in privacy sensitivity concern levels.

B. DATA MANAGEMENT CONCERNS

Respondents from all three countries had serious concerns regarding data management of provided dashcam footage compared to privacy sensitivity in general, as confirmed by Wilcoxon signed-rank tests: $z = 12.115$, $p < .0005$ for Korea, $z = 5.971$, $p < .0005$ for China, and $z = 7.877$, $p < .0005$ for Russia. To test if differences in data management concern scores exist among countries, a Kruskal-Wallis test was

TABLE 3. Mean and standard deviation concern scores across three countries.

Concerns	Korea		China		Russia	
	Mean	SD	Mean	SD	Mean	SD
Privacy Sensitivity	4.27	1.40	4.28	1.50	3.78	1.32
Recorded audio	4.97	1.79	4.37	1.83	3.69	1.92
Driving routes (GPS)	3.89	1.97	4.14	1.88	3.44	1.89
Video w/ traffic violation	4.50	1.83	4.42	1.73	4.00	1.81
Video w/o traffic violation	3.56	1.86	3.92	1.81	3.68	1.71
Bystander privacy	4.48	1.74	4.44	1.79	3.58	1.89
Passenger identities	4.24	1.92	4.41	1.85	4.32	1.82
Data Management	5.09	1.32	4.60	1.62	4.20	1.51
Misuse of shared video	5.21	1.61	4.62	1.81	4.31	1.87
Misuse of shared location	4.83	1.79	4.72	1.83	4.62	1.85
Identity exposure	5.17	1.65	4.65	1.92	4.05	1.95
Retaliation	4.88	1.71	4.40	1.91	3.96	1.93
Non-disposal of data	5.34	1.59	4.60	1.77	4.08	1.98
Trustworthiness	2.87	1.55	5.26	1.02	4.67	1.54
Police	3.01	1.76	5.74	1.12	4.71	1.78
Accident involved party	2.86	1.66	4.91	1.38	4.78	1.73
Insurance company	2.74	1.67	5.13	1.40	4.51	1.80

conducted. As the distributions of data management concern scores were not similar for all countries, only differences in distributions were investigated. Data management concern mean scores were significantly different, $\chi^2(2) = 64.188$, $p < .0005$. Post hoc pairwise comparison with a Bonferroni correction revealed that differences among all three countries were significant; Respondents from Korea had the highest data management concern scores followed by those of China and Russia.

Korean respondents expressed substantial concerns towards non-disposal of shared data item, which was the highest ranked item among five data management concern items. However, respondents in China and Russia had relatively low levels of concern towards non-disposal of shared data; the non-disposal of shared data concern was ranked fourth and third, respectively, with both values being less than the overall data management concern mean values.

Another apparent difference was the level of concern towards the misuse of shared location item. While misuse of shared location was the lowest item in Korea (ranked fifth with mean = 4.83, where overall data management concern mean = 5.09), it was the highest in both China (ranked 1st with mean = 4.72, where overall data management concern mean = 4.60) and Russia (ranked first with mean = 4.62, where overall data management concern mean = 4.20).

C. REQUESTER's TRUSTWORTHINESS CONCERNS

Respondents were asked to rate the level of trustworthiness towards a certain party—police, accident involved party, and insurance company—for managing personal information and video content included in shared dashcam footage. Overall, Korean respondents expressed significantly lower trust levels (2.87) when compared to other two countries' scores (5.26 for China and 4.67 for Russia) by Kruskal-Wallis test: $\chi^2(2) = 352.787$, $p < .0005$. Subsequent post hoc analysis of pairwise comparison with Bonferroni correction presented statistically significant differences in requester's trustworthiness scores among all three countries; Korea and China ($z = -17.854$, $p < .0005$), China and Russia ($z = 4.930$, $p < .0005$), and Russia and Korea ($z = -13.798$, $p < .0005$).

Apart from the absolute difference in the level of trust towards the requesting party, respondents from all three countries had high trust of the police. The police ranked as the most trusted requesting party in both Korea and China with statistically significant difference compared to the other two requesting parties (i.e., accident involved party and insurance company), as confirmed by pairwise Wilcoxon signed-rank tests following the significant Friedman test ($\chi^2(2) = 21.312$, $p < .0005$ for Korea and $\chi^2(2) = 106.631$, $p < .0005$ for China). Although the police ranked second in Russia with mean value 4.71, the difference from the top-ranked item, the accident involved party (4.78) was not significantly different as determined by the Wilcoxon signed-rank test: $z = 1.090$, $p = .276$.

Respondents generally had low trust towards the insurance company, which was ranked as the least trustworthy party in all three countries. Although the difference between the insurance company and accident involved party was not statistically significant in Korea ($z = 1.833$, $p = .067$), it was significantly lower compared to the police ($z = 4.069$, $p < .0005$) by the Wilcoxon signed-rank test. In China and Russia, it was significantly lower than both the accident involved party and police. One of the additional questions we asked examined concern regarding insurance company profit-seeking behaviors using provided dashcam video, where respondents from all three countries expressed considerable levels of concern in this matter. As suggested by the very low trust towards insurance companies in Korea (2.74), respondents' mean concern level towards insurance companies' profit seeking in Korea was 5.65 (SD = 1.37) in the 7-point Likert scale, 4.53 (SD = 1.83) in China, and 4.64 (SD = 1.92) in Russia.

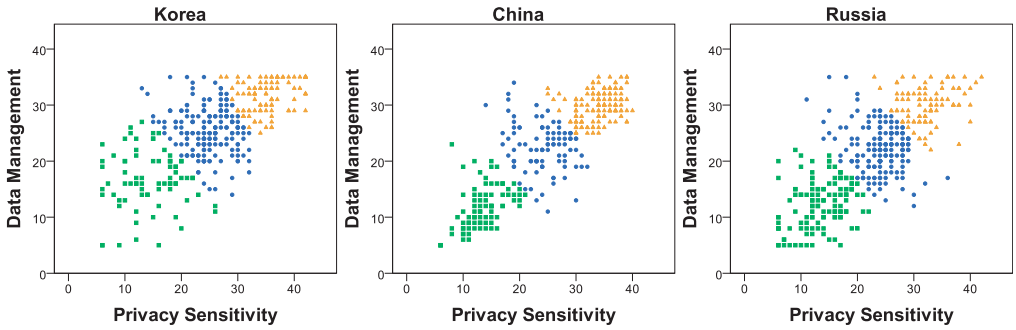

FIGURE 2. *k*-means clustering result of three privacy groups: High marked with squares, Medium with circles, and Low with triangles.

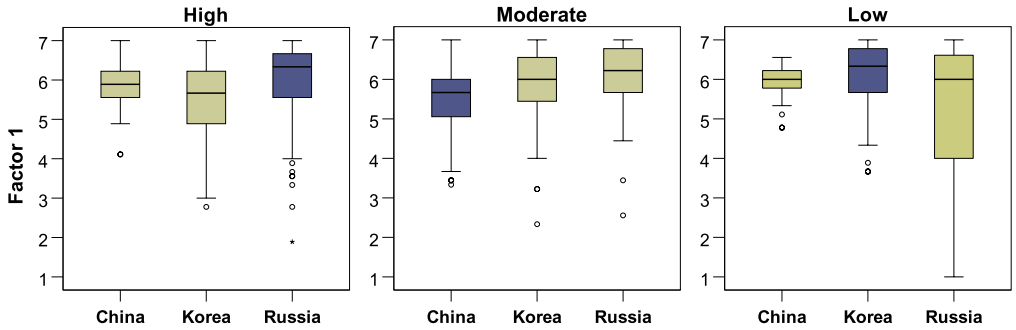

FIGURE 3. Factor 1 score differences across three privacy groups.

VI. MOTIVE DIFFERENCES ACROSS DIFFERENT LEVELS OF PRIVACY CONCERNS

This section answers the third set of research questions: *How are differences in levels of concern about privacy reflected in dashcam sharing motives across three countries? How are different nations related to any of these differences among privacy groups?* Based on our findings of motives and concerns, we analyzed how respondents' motives are related with their privacy concerns within a country and across countries.

Following the procedure in [64], we categorized the respondents into three privacy groups: 1) High 2) Moderate 3) Low, based on their concern levels using *k*-means cluster analysis, with $k = 3$ and a maximum number of iterations setting of 20. As a clustering variable for the concern level, a two-dimensional vector of 1) a privacy sensitivity score (i.e., a sum of six concern scores in privacy sensitivity) and 2) a data management score (i.e., a sum of five concern scores in data management) was calculated for each response. A trustworthiness score was not considered for the clustering because the trustworthiness was about reliability of personal data management rather than the level of privacy concerns. Figure 2 provides the visualized partitions for *k*-means clustering of three privacy groups.

After clustering, mean Factor 1 and Factor 2 scores across each privacy group were calculated for each country. Due to outliers and normality violation, a non-parametric Kruskal-Wallis test was conducted for comparing motive differences across different privacy groups. For Factor 1: reciprocal altruism and social justice, the results produced the following conclusions (see Figure 3).

For *High* privacy group, Russia had significantly higher Factor 1 score compared to China and Korea ($\chi^2(2) = 32.632$, $p < .0005$)—post hoc pairwise comparison with Bonferroni correction revealed that China (mean rank = 197.58) and Korea (mean rank = 173.08) had significantly lower Factor 1 scores compared to Russia (mean rank = 253.58) and there were no statistically significant differences between China and Korea ($p = .375$).

For *Moderate* privacy group, China had the lowest Factor 1 score ($\chi^2(2) = 28.538$, $p < .0005$)—post hoc pairwise comparison with Bonferroni correction showed that Korea (mean rank = 197.11) and Russia (mean rank = 224.81) had significantly higher Factor 1 scores compared to China (mean rank = 142.21) and there were no statistically significant differences between Korea and Russia ($p = .136$).

For *Low* privacy group, Korea had the highest Factor 1 score ($\chi^2(2) = 8.744$, $p = .013$)—post hoc pairwise comparison with Bonferroni correction showed that China (mean rank = 129.72) and Russia (mean rank = 133.97) groups had significantly lower Factor 1 scores compared to Korea (mean rank = 164.10) and there were no statistically significant differences between China and Russia ($p > .999$).

For Factor 2: monetary reward, Figure 4 shows Factor 2 scores for three countries within each privacy group. There was a statistically significant difference in Factor 2 score across the three countries for *High* and *Low*

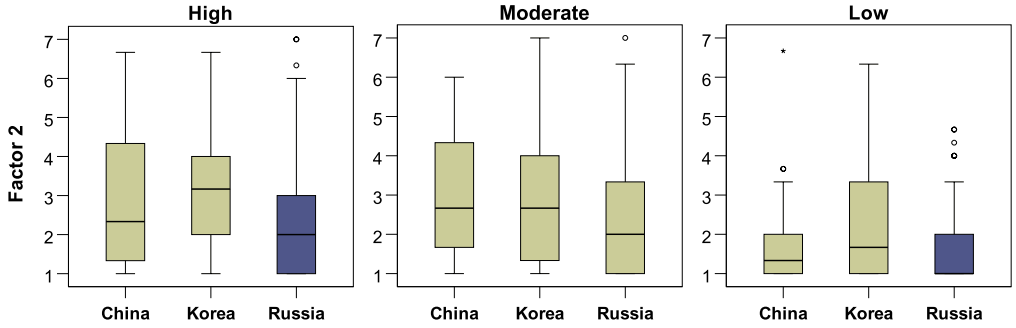

FIGURE 4. Factor 2 score differences across three privacy groups.

privacy group determined by Kruskal-Wallis test ($\chi^2(2) = 35.688$, $p < .0005$ for High and $\chi^2(2) = 17.513$, $p < .0005$ for Low), while no significant difference among the three countries was found for *Moderate* privacy group ($\chi^2(2) = 5.512$, $p = .064$). Post hoc pairwise comparison with Bonferroni correction revealed that Russia (mean rank = 176.65) had significantly lower Factor 2 score compared to Korea (mean rank = 231.44) and China (mean rank = 261.89) in *High* privacy group where no difference was found between China and Korea ($p = .165$). Factor 2 score of Russia (mean rank = 119.78) was significantly different from Korea (mean rank = 163.78) and China (mean rank = 151.56) as well in *Low* privacy group with no significantly difference between China and Korea ($p = .960$).

VII. DISCUSSION

A. MOTIVE DIFFERENCES

We studied whether the sharing motives of dashcam videos differ across nations (RQ1). Our analysis of sharing dashcam motives in China, Korea, and Russia has resulted in the discovery of two underlying factors—reciprocal altruism and social justice, and monetary rewards. In addition, we investigated how these factors are perceived differently by users from different nations. Respondents from all three countries were strongly motivated by reciprocal altruism and social justice, which is in line with a study conducted by Yang *et al.* [21] in which altruism and feeling good were the most common motivations in social Q&A across four countries. Although the country selection in this study prevented us from comparing differences between Asian and Western cultures (collectivist vs. individualistic societies), as was considered by Yang *et al.* [21], the strong reciprocal altruism and social justice motives from the three countries certainly highlight the significance of altruistic motivations in *social-purpose crowdsourcing* services as reported in prior studies [65]. One of the major arguments in evolutionary social or psychological studies is that reciprocal altruism is genetically rooted in humans and is thus not affected by other factors such as culture [66], [67]. Yet, there is another view stating that culture can form reciprocal altruism (or so-called prosocial behavior) [68]. Our analysis results strengthen the first statement that altruism and social motives are universal, regardless of cultural differences. Though the monetary reward factor scores were lower than the reciprocal and altruism factor scores in all three countries, respondents from Russia expressed significantly less motivation towards monetary reward as compared to respondents from China and Korea. Particularly, lower monetary motives in Russia could be caused partly due to its cultural norm or stereotype that making money off of others is immoral and perhaps remains deeply embedded in the Russian mentality [69].

B. PRIVACY CONCERNS

Regarding sharing privacy concerns (RQ2), the respondents from China, Korea, and Russia exhibited some discrepancies. The Russians had lower privacy concerns in general compared to Koreans and Chinese. According to the prior studies [51], [52], it is predicted that China could have lower privacy concerns than other nations due to its relatively lower uncertainty avoidance (30) and higher power distance (80). However, our results showed that Russia (uncertainty avoidance: 95 and power distance: 93) had the lowest privacy concerns. As alluded in conflicting results from prior cross-cultural studies [24], [28], cross-national differences in privacy concerns (and their relationship with motives) are rather nuanced and context-dependent, possibly due to diverse socio-cultural and political backgrounds, traffic safety and legal situations, and technology acceptance/adoption of dashcams (due to their various collected data types such as video, sound, and location). Regarding privacy sensitivity related items, Koreans were most concerned about the recorded audio, while concern towards disclosing driving routes was rather low. Chinese respondents also expressed a considerable amount of concern towards recorded audio or video content, rather than driving routes, which is consistent with the results in Korea.

Respondents generally had low concern towards driving routes (GPS) across all three countries. This could be because the amount and duration of shared dashcam footage is usually not very long, and thus driving route information in those short segments may not be sufficient to violate one's privacy, which can be inferred from the results where respondents had a much higher concern towards the GPS information if they were to share the location continuously while behind

the wheel. Respondents from all three countries had a significantly higher level of concern towards the data management of provided dashcam footage compared to privacy sensitivity, where respondents from Korea had the highest data management concern scores, followed by China and Russia. Possibly due to a recent accidental data disclosure, where companies inadvertently exposed the private information of hundreds of consumers [70], [71], respondents seemed to worry much more about the secondary organization or agency that handles the data, rather than the generated data itself (i.e., the dashcam footage).

C. MOTIVE DIFFERENCES ACROSS PRIVACY GROUPS

To understand how privacy concerns are reflected in sharing motives (RQ3), we divided respondents into three privacy groups similar to Westin's grouping, namely High, Medium, and Low. Comparing motives differences across different privacy groups helps us to gain insights into privacy calculus behaviors [53] across different nations—information sharing happens if a user's perceived sharing benefits/motives outweigh the perceived costs of privacy concerns; e.g., disclosing personal information for monetary and altruistic reasons in online shopping [54]. While Factor 1 (reciprocal altruism and social justice) scores did not show clear patterns across different cultures, Factor 2 (monetary reward) scores showed a consistent pattern. The ''Low'' privacy groups had lower scores of Factor 2 (monetary reward) when compared to other groups. This partly means that those who have less privacy concern have a lower tendency of seeking monetary reward, or possibly lower valuation of their privacy risks [72]. Factor 1 scores are relatively high when compared to Factor 2 scores, but our results did not show that privacy concern levels are strong correlates to altruism and justice motives. Given that motives differ across different privacy groups, our results partly support privacy calculus behaviors related to monetary reward, but we do not find notable patterns in altruistic motives across different nations.

D. CROWDSENSING SYSTEM DESIGN IMPLICATIONS

Advanced sensing and recording has become extremely ubiquitous due to recent advances in intelligent systems, including ADAS and autonomous vehicles. Dashcams as *continuous mobile sensing and recording devices* can capture diverse scenes and offer advanced driver-assistance services. Despite privacy concerns, the wide coverage and contextual diversity of captured data along with advanced sensing and networking capabilities bring new opportunities for designing various *crowdsensing* services. It is possible to provide a *real-time* dashcam video sharing service which is run by the authority where a scene of interest is automatically extracted, data authenticity is verified for data sharing, and the users are rewarded [10]. There are also other forms of *collaborative crowdsensing services* such as accessibility mapping [12], community policing [35], and citizen science projects [73]. Our findings of sharing motives and privacy concerns can be applicable to building these crowdsensing services particularly when encouraging sharing motives (e.g., altruistic framing, channel preferences, and monetary reward expectation) and supporting privacy-preserving tools (e.g., dashcam installation differences and types of data to wish to protect). When building such crowdsensing systems, a care must be taken to consider privacy risks related to advance sensing and artificial intelligence systems; e.g., facial recognition for racial profiling [74].

E. LIMITATIONS

Our work only focused on nations where dashcams are well adopted, but these nations belong to a collectivistic society according to Hofstede's model [48]. There should be a follow-up study in individualistic societies (e.g., United States) to generalize our findings, but at this point, dashcam adoption in most western nations is fairly low. In addition, the current work is mainly focused on dashcam owners' motives and privacy concerns for sharing. Another direction for future work is to consider drivers without dashcams, passengers, and pedestrians to better understand bystander privacy concerns. It would be interesting to investigate the privacy concerns of drivers who decide not to use dashcams due to privacy concerns, or dashcam non-users [75].

VIII. CONCLUSION

Dashcams are pervasive recording devices that capture continuous footage from a vehicle's perspective. These devices are surprisingly common in many countries such as China, Korea, and Russia. Furthermore, recent semi-autonomous vehicles even support more advanced surveillance modes with real-time sensing and recognition. With its growing usage, dashcam video sharing has become a crucial tool for accident investigation, social awareness, and entertainment. The growing presence and impact of dashcams have highlighted the importance of understanding sharing motives and privacy concerns for designing pervasive recording devices and data sharing services. Through survey studies conducted in China, Korea, and Russia, we systematically investigated how the major motives and concerns behind sharing dashcam videos differ across multiple nations. The results indicated that across all nations, reciprocal altruism and social justice motives are much greater than monetary motives. However, we found that national differences indicated subtle variations in concerns related to dashcam video sharing such as privacy sensitivity of shared data, data management practices, and the requester's trustworthiness. Cross-national differences in privacy concerns and their relationship with motives were nuanced and context-dependent. We call for further cross-national HCI studies on motives and privacy concerns of information sharing with pervasive sensing technologies.

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