# Motives and Concerns of Dashcam Video Sharing

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## ABSTRACT
Dashcams support continuous recording of external views that provide evidence in case of unexpected traffic-related accidents and incidents. Recently, sharing of dashcam videos has gained significant traction for accident investigation and entertainment purposes. Furthermore, there is a growing awareness that dashcam video sharing will greatly extend urban surveillance. Our work aims to identify the major motives and concerns behind the sharing of dashcam videos for urban surveillance. We conducted two survey studies (n=108, n=373) in Korea. Our results show that reciprocal altruism/social justice and monetary reward were the key motives and that participants were strongly motivated by reciprocal altruism and social justice. Our studies have also identified major privacy concerns and found that groups with greater privacy concerns had lower reciprocal altruism and justice motive, but had higher monetary motive. Our main findings have significant implications on the design of dashcam video-sharing services.

## ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous; K.4.1. Public Policy Issues: Privacy

## Author Keywords
Dashcams, Video Sharing, Privacy Concerns, Motivation, Smart Cars

## INTRODUCTION
Vehicle dashcams (also known as dashboard cameras, car digital video recorders, or blackboxes) enable high-quality video recording of external views and automatic collision/motion sensing that provide evidence in case of unexpected traffic-related accidents and incidents (e.g., crashes on the road or damages to a parked vehicle) (see Figure 1). Dashcams complement existing Event Data Recorders (EDRs), which can record only low-level vehicle states such as the speed, steering, and braking at the time of a crash [8]. Dashcams are gaining popularity in many parts of Asia and Europe. For example, according to a recent survey in Korea [44], the rate of dashcam adoption exceeded 60% as of February 2015. Other countries with high adoption rates include Russia and China. In these nations, use of dashcams has now become an integral part of the driving experience of individuals.

**Figure 1. Dashcam installation on the front windshield [1]**

Interestingly, drivers have been actively sharing various types of events captured by their dashcams, ranging from insurance fraud attempts to reckless driving behaviors and automobile crashes. One of the famous events was the 2013 entry of the Chelyabinsk meteor into the earth's atmosphere over Russia. This event was captured from many angles by dashcams, and footage was virally spread over social network sites such as YouTube, Facebook, and Twitter. In Korea, citizens have been actively participating in sharing dashcam videos to help those who need objective evidence. It is not uncommon to see large banners near accident sites or postings in local online forums and popular portal sites looking for dashcam witnesses. Furthermore, a number of local police agencies have been running citizen campaigns for sharing dashcam footage for purposes of accident and crime investigation.

Mobile video recordings of urban streets (or crowdsensing on the wheel) will greatly extend urban surveillance coverage, thereby complementing existing fixed cameras and sensors on the streets. Recently, researchers have been attempting to build online platforms to demonstrate the feasibility of organizing dashcam-based crowdsensing campaigns [9, 34]. For


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example, the local authority maintains an accident database and crowd contributors, using their smartphones, periodically query the database to check for any matching accident clips to upload [34]. Furthermore, researchers have even envisioned real-time video sharing to enhance navigation safety and driving situation awareness (e.g., accidents, flood, fire, and road damage) [40, 10, 42, 19]. Designing such intelligent systems requires a comprehensive understanding of dashcam users' motives and concerns, e.g., to determine how to encourage user contribution and how to deal with users' privacy concerns. However, no prior studies have systematically explored what motivates users to share dashcam video and how privacy concerns are related to the motives in an urban surveillance context. So far, recent user studies focused mostly on examining data sensitivity and bystander reactions to emerging technologies (e.g., wearable glasses and cameras) [37, 15, 45].

In this paper, we aim to identify the key motives and concerns behind the sharing of dashcam videos for urban surveillance, and to understand how user motives differ across groups with different privacy concerns. We designed and conducted two user studies to answer these research questions. In Study 1, we conducted a survey study (n=108) that sought for free-text input on sharing motives and concerns, and then extracted the key themes behind the motives and concerns when sharing dashcam videos. In Study 2, and based on the initial survey results and existing motivation scales, we designed a motive/concern questionnaire and then conducted another survey study (n=373) to perform a statistical analysis of the motives. Furthermore, we clustered users based on their privacy scales into three groups, which are similar to Westin's privacy classification (e.g., High and Fundamentalist, Medium and Pragmatist, and Low and Unconcerned) [26], and then analyzed how motives differ across these different groups.

Our results showed that motives for dashcam video sharing were twofold: reciprocal altruism/social justice and monetary reward, though participants were by far more strongly motivated by reciprocal altruism and social justice than by monetary rewards. A mixture of reciprocal altruism and social justice is a main motivator in the case of dashcam video sharing. In addition, we identified unique concerns related to dashcam video sharing, such as concerns about privacy sensitivity of recorded data, data management practices (e.g., misuse, identity exposure, and retaliation), sharing efforts (e.g., examining dashcam devices and uploading content), and trust level differences across requester entities (e.g., police, insurance company, and victims). In fact, sharing motives varied across groups with different levels of privacy concerns; that is, the group with higher privacy concerns had a significantly lower reciprocal altruism/justice score but had a higher monetary score than the group with lower privacy concerns.

Our findings are of capital importance in building successful online services for dashcam video sharing, and suggest some practical design issues for building an online service for dashcam video sharing: that is, encouraging motivation for sharing, supporting privacy preserving tools, dealing with trust and policy issues, and matching between the requester and the provider.

## DASHCAM OVERVIEW

The basic features of dashcams include external view recording, internal audio recording, and location annotation with GPS information (e.g., Garmin Dash Cam 35) [20]. These features complement existing EDRs, which can only record low-level vehicle statuses such as the speed, steering, and braking input from the driver a few seconds immediately prior to and during a crash [8]. For external view recording, recent models of dashcams typically support two channels: a front view camera with Full High-Definition (Full HD) quality and a rear view camera with HD quality. Dashcams continuously record external views and save the video files in short segments. An interesting recent trend is that dashcam manufacturers are increasingly incorporating Advanced Driver Assistance System (ADAS) features such as forward collision warning and lane detection [42]. For recording awareness, there is a visual cue such as a blinking LED that signifies a dashcam-equipped vehicle. Depending on the video quality, a dashcam can store up to 13, 20, and 48 hours of video data in Full HD, HD, and VGA quality, respectively (assuming 32GB of memory size). In addition, event-based recording enables the automatic recording of external views for 10-30 seconds before and after notable events happen (e.g., external impact, motion changes, or manual input). While a vehicle is moving, an impact event is detected by processing on-board accelerometer data. When a vehicle is parked, significant motion changes (either in the front or in the rear view) are detected by processing video streams. Data storage is separately allocated to different recording modes (e.g., 40% for continuous recording, 20% for impact recording, and 40% for motion recording). Due to limited storage, in each mode, the oldest video files are constantly overwritten with the newest video files (a process known as automatic loop recording).

A majority of dashcams do not have an onboard screen, but recently, high-end dashcams are increasingly being equipped with an on-board touch screen and/or wireless connectivity for convenient video access with smartphones. For safety reasons, the on-board screen is usually turned off while a vehicle is on the move. Users can manipulate dashcams with onboard buttons (e.g., mic on/off, manual video recording start/stop, and screen on/off). PC-based player software also supports more delicate configurations (e.g., sensitivity control of impact/motion sensing, mic/speaker control, and visual cue control). To review video footage, a user can use the on-board screen if it is available. Alternatively, the memory card can be taken out and PC-based player software can be used to search for the video footage of interest and to review multiple channel videos. At the time of this writing, the available PC-based players generally lack privacy-preserving tools that are essential for video sharing (e.g., clipping video parts, removing audio tracks, locations, and sensor data).

## RELATED WORK

We start with summarizing prior studies on privacy concerns about information sharing and pervasive surveillance, and then we make an overview of sharing motives in various online systems.

### Privacy Concerns about Personal Information Sharing

Our work considers two aspects of privacy concerns in the context of dashcam video sharing: i.e., individuals' privacy sensitivity to the sharing of their dashcam footages, and information management practices of the recipients such as the victims and the police.

The first aspect is mainly related to disclosing personal information. Privacy sensitivity of various personal information items varies widely, ranging from very sensitive information (e.g., social security number, credit card number, and medical records) to less sensitive information (e.g., full name, email address, and favorite TV show) [2]. These items can be categorized based on the level of sensitivity [38]. In the era of social networks, personal information such as photos and locations is often disclosed online. Ahern et al. [3] studied location-based photo sharing with Flickr and found that photo content such as the image of a person or of an object is more related to privacy concerns than meta-data such as location and time. The major themes of concerns were personal security risk, online identity exposure, and social disclosure of sensitive information. Consolvo et al. [13] studied whether and what users are willing to disclose about their current location via social networks. They found that the most critical factors include who was requesting, why the requester wanted the participant's location, and what level of detail would be most useful to the requester. The participants wanted to share only if location disclosure would be useful to the requester.

An organization's personal information management practices are the other aspect of privacy concerns. The U.S. Fair Information Practices (FIPs) standards [27] provide the major guidelines such as purpose specification, individual participation on data access/correction, collection (i.e., collecting only minimal, relevant data that are used and maintained by authorized personnel), and reasonable security. Smith et al. [46] proposed more concrete dimensions for privacy scale development; i.e., collection, unauthorized secondary use for different purposes, improper access to information by unauthorized users, and errors in personal data. These frameworks provide useful grounds for investigating an individual's privacy sensitivity and an organization's personal information management practices. For example, Ackerman et al. [2] showed that information disclosure in e-commerce sites was largely influenced by based on secondary usage, data collection (purpose and relevant data), proper usage/disposal, and site access/trust.

### Privacy Studies on Pervasive Surveillance

We reviewed recent privacy studies on various recording devices, ranging from traditional fixed cameras to wearable and mobile cameras. Nguyen et al. [36] studied people's perceptions of pervasive video recording such as closed-circuit televisions (CCTV), webcams, and camera phones. They identified that, due to repeated exposure of continuous surveillance, concerns for collection were lower than those for improper access and secondary use, but participants wanted improved awareness on data collection and usage. In such environments, it is known that people generally lack the tools, motivation, power, or knowledge to control and access the recording environments [32]. Prior studies concurred that privacy concerns are highly contextualized [18, 32, 36, 15, 21]. Friedman et al. [18] studied privacy concerns regarding real-time video broadcasting of public spaces. They identified that people expressed some level of privacy concerns even in the public places, and privacy judgments were dependent on multiple facets such as physical harm, psychological well-being, and information consent, and gender. Massimi et al. [32] found that people's expectations about the existence of recording differed widely based on the perceived privacy level of a space; recording private spaces (e.g., home) was less preferred than recording at public and shared spaces.

The extent of pervasive surveillance has been significantly increased in recent years due to the advances in emerging smart technologies such as smart home equipment (e.g., smart thermostats, home security systems, and smart TVs) and mobile recording technologies (e.g., wearable glasses, wearable cameras, and dashcams). Choe et al. [12] investigated sensing and recording technologies in the home and identified the types of privacy concerning activities such as embarrassing self-appearances (e.g., nudity and walking in underwear) and oral expressions (e.g., singing and conversation). As in prior studies on traditional cameras [18, 32, 36, 15, 21], recent studies on wearable cameras (e.g., SenseCam and wearable glasses) showed that privacy concerns are nuanced in relation to the major contextual factors such as people, objects, activities, and locations [37, 15, 21]. Wearable cameras were well accepted among bystanders, and wearers did care about bystander privacy as well. Bystanders expressed privacy concerns due to the subtleness, ease of recording, and its lack of prevalence [15]. Wearers were willing to share images if there were any good reasons to do so, as long as contextualized privacy concerns were absent [21].

So far privacy concerns on vehicle-based sensing and recording have been rarely studied in the field of HCI. Sleeper et al. [45] investigated the perceived benefits and concerns, by asking study participants to imagine a hypothetical smart car with sensing and recording technologies (e.g., external cameras, GPS, and EDR). They found that vehicle-based sensing and recording will significantly impact people's mental models of recording awareness due to vehicle mobility and coverage. Furthermore, perceived benefits such as assisting drivers, capturing accidents, and promoting public safety have a positive impact on technology acceptance, despite drivers' concerns with capturing sensitive activities such as bad/illegal driving behaviors and embarrassing activities. Our work extends that of Sleeper et al.'s work [45] in that we studied the motives and concerns behind the sharing of dashcam footages by those who have been already using dashcams, which can be considered as a representative vehicle-based sensing and recording technology.

### Motivation for Participation in Crowdsourcing

Researchers studied the motivation for participation in various crowdsourcing contexts such as knowledge sharing, volunteer geography, open source software, social-purpose work, and online labor markets. Crowdsourcing motives are largely dependent on a mixture of intrinsic factors (e.g. enjoyment, and feelings of gratitude and respect) and extrinsic factors (e.g. monetary and social rewards) [24, 43]. The motivation for knowledge sharing in social Q&A results from both intrinsic and extrinsic factors; that is, altruism is the leading factor,

followed by business motives, learning, hobbies, and earning points [35]. Similarly, Budhathoki and Haythornthwaite [6] found that contributors to OpenStreetMap, a well-known volunteer geography tool are motivated both intrinsically (e.g., learning, self-efficacy, and fun) and extrinsically (e.g., community, project goals, and monetary rewards). In the case of social-purpose crowdsourcing (e.g., supporting public libraries and helping people with disabilities), Kobayashi et al. [25] extended existing motivation frameworks by additionally distinguishing whether motives are personal or social (e.g., among intrinsic motives, skill and fun are personal, whereas social contribution and community identification are social).

However, when monetary incentives are involved such as Mechanical Turk and Google Answers, researchers found that monetary motives are considered to be more important than the intrinsic motives [43, 24, 17, 29]. Research from psychology and behavioral economics shows that monetary incentives may crowd-out intrinsic and social motivators [7]. In reality, due to diverse user motives, only a subset of the population may be motivated by monetary rewards, and this effect may not be critical. Our work studies sharing motives of dashcams as a representative system for emerging sensing and recording technologies in the growing field of intelligent vehicles [30, 28, 42, 19]. Leveraging the sharing motives is critical in designing crowdsourcing systems whose operations are largely based on user contributions.

## STUDY 1

We performed an online survey to understand the key factors associated with dashcam video sharing, which was divided into three parts: (1) usage purposes, (2) sharing motives, and (3) sharing concerns.

### Method

#### *Survey Content*

The survey was composed of 28 questions, including items related to demographic information. We began the survey with questions regarding demographics (e.g., gender, age, etc.) followed by inquiries about dashcam specifications (e.g., number of dashcam channels, dashcam price, etc.). To gauge usage purposes, we asked three questions; *"Why do you use a dashcam?"*, *"Have you ever checked your own dashcam?"*, and *"Have you ever checked or wanted to check others' dashcams?"*. All questions were in free-text format. Responses to these three questions were manually coded, and then the key factors were extracted for each case. Two questions were used to understand the sharing motives. We first asked whether respondents were willing to check their own dashcam if someone involved in a car accident was looking for a witness. We then asked about their willingness to actually share their dashcam footage. Free-text responses that contained information about sharing motives from either questions were merged into one codebook to obtain an overall insight into the sharing motives. Respondents answered three questions regarding sharing concerns related to requester type, content information, and location information categories. Respondents were not limited to a given category, so all free-text responses from these three questions were merged into one codebook as an entire set. Then, two researchers collaboratively categorized all survey responses into similar themes by using affinity diagramming in repeated iterations until a consensus was reached.

#### *Demographics and Recruitment*

A total of 108 respondents who self-identified as dashcam users completed the survey over 2 weeks (July 16–July 31, 2015). Respondents were skewed to male (89% male, 11% female). This skewness is attributed to gender effects on car maintenance, including dashcam management (e.g., installing and checking). Among the core tasks in a common household, car maintenance is considered to be a man's task according to the time use survey results [5]. Furthermore, significantly more single men than women perform car maintenance [41]. The largest age group of the respondents was the 20s group, accounting for 42% of the total number of respondents (30s, 33%; 40s, 19%; 50s, 6%). This skewed age distribution was partly due to the fact that the recruitment took place online, because younger people have more Internet access than older people [31]. Posting websites included university community websites, popular car-related information sharing community websites, and social networking sites. As incentive for participation, each respondent was given a chance to win a gift card raffle of approximately $10 in value (a total of 40 gift cards).

### Results

#### *Usage Purposes*

Our analysis showed that the primary usage purpose of dashcams was for securing evidence for traffic-related accidents, especially when the respondents were involved in the accident and needed to check the dashcam to determine who was at fault. In addition, respondents wished to check others' dashcams when a certain scene was not captured by their own dashcam.

*Evidence for Traffic-Related Accidents and Incidents*: A majority of respondents (93.5%, 101/108) reported that their primary purpose for using a dashcam was to secure evidence for traffic-related accidents/incidents . Responses pertained to situations both prior to and after a traffic accident/incident. For example, people use dashcam footage as evidence after an accident, which serves an important role in determining who was at fault or in resolving conflicts between drivers. Dashcams also function as a protection device; a dashcam in a parked car tends to raise awareness in other drivers, *"Because other people can easily see that I have a dashcam installed in my car, drivers pay much more attention when they get in and out of their car, trying not to make an accidental scratch/dent on my car's door"* (P77). Respondents also mentioned dashcam usage for financial benefits since some insurance companies offer a discount on insurance premiums for having a dashcam.

*Checking My Own Dashcam*: A total of 80.6% (87/108) of respondents answered that they have checked their own dashcams for the following reasons, with multiple answer selections allowed: events related to their own car accidents (58.6%), events related to others' car accidents (29.9%), functionality check (20.7%), and personal driving record management (9.2%). A typical instance for checking events related to their own car accidents is as follows, *"When I got into an accident, I wanted to check my dashcam to see whose fault it was"* (P73). Checking for events related to other cars included witnessing an accident involving other cars or witnessing reckless driving behaviors/traffic violations of other drivers. For example, *"A car right in front of me got into an accident with other cars. I thought that my dashcam caught the scene, so I wanted to check it"* (P17).

| Motives | Frequency |
|---|---|
| To determine the truth and resolve unjust accusation | 43.8% (32/73) |
| To help other people | 31.5% (23/73) |
| To reciprocate | 16.4% (12/73) |
| To do right for public good and social justice | 16.4% (12/73) |
| To receive a monetary reward | 6.8% (5/73) |

**Table 1. Summary of reasons for sharing dashcam footage.**

*Checking Others' Dashcam*: A total of 25% (27/108) of respondents answered that they wanted to check others' dashcams mainly because it can function as evidence, especially when an accident was not captured by their own dashcams due to limited recording angles (only front/back views) or device malfunction. The most common event was described as, *"I wanted to check the dashcam of a car that was parked across my car when I found scratches on the side door"* (P104). Another case in which others' dashcam could be used was for hit-and-run accidents. Respondents reported experiences of a third-party's dashcam footage aiding in investigation of finding the offender in hit-and-run accidents.

### Sharing Motives

We categorized 73 free-text responses about sharing motives (see Table 1). The major themes comprised intrinsic motivational factors (e.g., determining truth, helping others, reciprocating, and upholding social justice) and an extrinsic motivational factor (e.g., receiving monetary reward).

We found that intrinsic motivational factors outweighed extrinsic motivational factors in sharing motives. A common response was the desire to uncover the truth about accidents. Respondents wanted their dashcam footage to be used as objective evidence for accidents, even when they are not directly involved. Respondents especially expressed a strong motivation to help resolve unjust accusations: *"If I can help a person who is being charged unfairly, I am willing to provide help by sharing my dashcam footage"* (P30).

Many people were willing to share their dashcam footage, regardless of the presence of incentives or the identity of the requester, simply to help other people. For example, responses often resembled statements like *"If I can help other people by sharing my footage, I am more than happy to share"* (P72), or *"Someone asks for help because he/she needs it, and there is no reason why I should not fulfill that request"* (P27).

Other motives included the principle of reciprocity, for example, *"I could be in an accident one day, and when that happens I would want other people to share their dashcam footage with me"* (P81).

Another aspect dealt with the idea of social justice; respondents were willing to share not only for the sake of helping individuals involved in accidents, but also for the sake of public good and the achievement of social justice, where one respondent wrote *"Although the main purpose of using a dashcam is for the protection of my vehicle and my safety, I will share my dashcam footage regardless of incentives if it is for public good"* (P63). Also, two individuals simply mentioned that they were willing to share their footage to achieve social justice (P79, P99).

| Concerns | Frequency |
|---|---|
| Privacy Sensitivity | 59.2% (42/71) |
| Personal information | 14 |
| Recorded private conversation | 11 |
| Provider's traffic violation | 8 |
| Driving routes | 4 |
| Identities of fellow passenger identities | 3 |
| Bystander privacy | 2 |
| Data Management | 26.8% (19/71) |
| Data misuse | 14 |
| Data breach/disposal | 5 |
| Requester's Trustworthiness | 39.4% (28/71) |
| Police | 17 |
| Accident-involved party | 6 |
| Insurance company | 5 |
| Miscellaneous | 7.0% (5/71) |

**Table 2. Summary of concerns about sharing dashcam footages.**

Only 6.8% of respondents reported that they would share their dashcam footage solely for monetary reward, as in *"I would only share my dashcam footage if there is a financial reward"* (P5).

### Sharing Concerns

We categorized 71 responses about concerns regarding dashcam video sharing (see Table 2). The major themes included privacy sensitivity concerns about shared content (e.g., driver identity, traffic violation, driving routes), data management concerns (e.g., misuse and proper disposal of shared content), and requester-related concerns (e.g., trust, security, attitude).

*Privacy Sensitivity Concerns*: Respondents expressed general concerns about disclosure of personal information contained in the dashcam footage and raised privacy sensitivity issues on recorded conversations, driver's traffic violation, driving routes, and passenger and bystander's identity. Privacy concerns about conversations were related to personal relationships and job-related topics. One respondent stated, *"If the footage I am about to share includes a phone call with my co-worker discussing a company's confidential information, I might get in trouble for sharing"* (P95). The possibility of receiving punishment due to traffic violation in the video is another major concern; *"I would not share my dashcam footage if I get fined based on driving behavior or traffic violation"* (P70). Respondents commented that their location information (i.e., moving path) is relatively less concerning because the shared video clip will contain location information near the requested area. One participant commented, *"I do not see any disadvantages in sharing my location"* (P34). Our respondents also expressed concerns about the privacy of third parties such as passengers and bystanders (i.e., other drivers and people on the street).

*Data Management Concerns*: Besides privacy sensitivities, our respondents were apprehensive about how the videos would be handled after sharing. Major concerns involved misuse of shared data. Video providers generally felt uncertain about how the shared footage will be used by the requesters. There were concerns about misuse such as criminal activity and illegitimate surveillance. Also, respondents were concerned

about the lack of proper disposal after use; *"You never know if your shared footage was properly disposed or spread to other people, unless there are strict regulations"* (P7).

*Requester's Trustworthiness Concerns*: Concerns related to the type of the requester was another major theme. P14 expressed, *"Depending on who views and judges the accident situation, there will be different interpretations. I have to be mindful of the recipient when I'm sharing my dashcam footage"*. Because respondents were concerned about the trustworthiness of the requesting party, they wanted the police or law enforcement officers to organize dashcam sharing. The reasons provided for the higher level of trust toward the police include the following: *"... police request is an 'official' process"* (P70), *"The police is capable of fairly deciding who the victim is"* (P15), *"I feel much safer"* (P20), and *"I can trust the police"* (P105). If dashcam footage was to be shared directly with the person involved in the accident, respondents expressed an additional concern about the recipient's identity. They commented that it would be difficult for them to check the recipient's identity and credibility. Accident-involved requesters may cherry-pick video clips to produce a favorable outcome. Furthermore, respondents were concerned about retaliation: *"If my shared footage turned out to work against the person who is involved in the accident, he/she could want revenge against me, as my identity is already known to the person"* (P30). Respondents reported concerns about insurance companies' usage (7.04%), because, during claims processes, these companies often use dashcam videos to minimize their loss (thereby seeking more profits): *"I am reluctant to share my dashcam footage with insurance companies since they would only care about making profit out of the situation"* (P46).

*Miscellaneous concerns*: Miscellaneous concerns were related to the logistics of the sharing process. Since most dashcams do not have wireless connectivity, users felt some burden when they need to take out the memory card and transfer its data to a computer for footage sharing. For example, two participants mentioned that the sharing process itself is too troublesome (P96, P101), and one participant pointed out that it takes time and effort to find the relevant parts (P31).

## STUDY 2

We used the Study 1 results to design the second survey questionnaire and performed a quantitative analysis on 1) respondents' motivation for participation, 2) their privacy attitudes and other related concerns, and 3) the relationship between motivation and privacy attitudes.

### Method

We designed an online survey composed of four parts. First, we asked the users' demographic information (e.g., gender, age) and vehicle and driving related information (e.g., dashcam model, dashcam usage period, car model, driving years, and car accident experiences).

Second, we created a motive questionnaire that consisted of 12 items in a 7-point Likert scale. Based on the explorative study (Study 1) and literature review results, we carefully selected the motivation subscales, namely altruism, reciprocity, social justice, and monetary rewards. Altruism is a behavior performed without expecting any future reward and is carried out mainly to benefit others [47]. This corresponds to our motive theme of "To help other people." We modified three items from Budhathoki and Haythornthwaite [6]; e.g., "It is important to help others by providing a dashcam footage without expecting anything in return." Reciprocity is the practice in which a person who has gained something from another individual feels inclined to give something back in return to sustain ongoing supportive exchanges [48]. We modified three items from Cho et al. [11]: e.g., "I expect other people to help me, so it is only fair for me to help them by sharing my dashcam footage." Social justice is the concept in which people are willing to risk their own welfare to ensure that others are treated fairly [23, 14]. This concept encompasses both motive themes of "To determine truth in accident and resolve unjust accusation" and "To do right for public good and social justice." We adapted one item from Dean's work [14] and developed two other items based on participants' responses: e.g., "sharing dashcam footages helps to achieve justice in society." Regarding monetary rewards, we adapted three items from Budhathoki and Haythornthwaite [6]: e.g., "I will make financial profits by sharing dashcam footages."

Third, we asked privacy concerns and related questions that were based on the explorative study (Study 1), i.e., six items for measuring privacy sensitivities (e.g., audio, location, driving, passenger, bystanders), five items for measuring personal data management concerns (e.g., misuse of video and location, identity exposure), three items for measuring data management trusts (e.g., police, insurance company, those involved accidents), two items for measuring sharing effort, one item for measuring the concern of insurance companies' profit-seeking behaviors.

Finally, we asked questions about the respondents' willingness to participate in crowdsourcing activities of sharing videos, depending on the organizer types, i.e., the police and non-governmental organizations (NGOs). For timely video footage search, we also asked whether they are willing to always share their locations to an organizer whenever they are behind the wheel.

We conducted the online survey with those who self-identified as dashcam users for one week in the first week of September 2015. Participants were recruited similarly as in Study 1. A total of 373 respondents completed the survey (after removing incomplete and random responses). There were 343 males (92.0%) and 30 females (8.0%), with age groups of 20s (24.4%), 30s (61.1%), 40s (13.1%), and 50s (1.3%). When compared to Survey 1 participants, we had a significantly larger group of participants in their 30s, but in both studies, younger generations in their 20s and 30s were dominating since they are generally more active online than older generations [31]. The average driving experience was 8.47 years (SD = 5.91), average dashcam usage was 2.09 years (SD = 0.83), and 246 participants (66.0%) had a car accident experience. At the end of the survey, we randomly selected 40 participants and rewarded each of them with a gift voucher worth about $10.

| Subscales | Motivation | Factor Loading | Mean | SD |
|---|---|---|---|---|
| | Factor 1: Reciprocal altruism & Social justice (Cronbach's alpha = .878) | | 5.82 | 0.92 |
| Social justice | I share my dashcam footages to achieve social justice. | .804 | 5.75 | 1.29 |
| Altruism | I share my dashcam footage because those who are in need of videos will use my contribution. | .798 | 5.81 | 1.23 |
| Social justice | Sharing dashcam footages helps to achieve justice in society. | .774 | 5.78 | 1.31 |
| Reciprocity | I expect other people to help me, so it's only fair for me to help them by sharing my dashcam footage. | .754 | 5.46 | 1.50 |
| Reciprocity | If will actively share my dashcam footages to help others, if I was helped by others' dashcam footages. | .752 | 6.27 | 0.99 |
| Reciprocity | If I receive dashcam footages from other people, I should share my footages with others in return. | .661 | 5.86 | 1.30 |
| Altruism | It is important to help others by providing dashcam footage without expecting anything in return. | .621 | 5.66 | 1.36 |
| Social justice | If sharing my video footages can resolve an unjust accusation or a wrong treatment, I will actively help victims. | .616 | 6.48 | 0.82 |
| Altruism | I expect dashcam users to actively contribute answers without expecting anything in return. | .611 | 5.31 | 1.57 |
| | Factor 2: Monetary reward (Cronbach's alpha = .897) | | 2.78 | 1.50 |
| Monetary reward | I need financial benefits to share my dashcam footages. | .919 | 2.64 | 1.60 |
| Monetary reward | I will share dashcam footages to make financial profits. | .907 | 2.77 | 1.69 |
| Monetary reward | I will make financial profits by sharing dashcam footages. | .870 | 2.95 | 1.66 |

**Table 3. Summary of factors and individual items**

## Results

### *Sharing Motives*

We conducted an exploratory factor analysis on the survey responses of motivation items to extract the underlying concept. We extracted principal components with orthogonal rotation (varimax). We used the Kaiser-Meyer-Olkin measure to verify the sampling adequacy of the analysis (KMO = 0.878). We found two factors with eigenvalues over 1, explaining 57.0% of the variance. A cut-off value of 0.5 for the factor loadings drew two factors being found without any exclusion of items. Table 3 shows the factor loading after the rotation.

The results showed that Factor 1 contains the subscales of altruism, reciprocity, and social justice. These items are very strong motives for dashcam video sharing (M = 5.82, SD = 0.92). Factor 2 consists of the items corresponding to the monetary rewards. The items comprising this factor show that respondents are marginally motivated by monetary rewards for dashcam video sharing (M = 2.78, SD = 1.50).

We conducted a series of multiple linear regression analyses to determine whether personal profiles (e.g., vehicle price, age, gender, years of driving) and dashcam usage (e.g., years of usage, accident usage) are related to the major motives. We were able to find only a weak model for the monetary reward factor ($R^2$ = .074). Interestingly, age was a significant predictor: younger participants were more motivated by monetary reward. A one-way analysis of variance (ANOVA) showed that there were significant differences across different age groups ($F(3, 37) = 4.14$, $p < .007$): 20s: 3.15 (SD = 1.63), 30s: 2.71 (SD = 1.44), 40s: 2.56 (SD = 1.43), and 50s: 1.27 (SD = 0.60).

### *Sharing Concerns*

*Privacy Sensitivity Concerns*: Since dashcams continuously record external videos, internal audio and GPS, we studied the privacy concerns about different information items. A Friedman test, a non-parametric (or distribution free) alternative to the one-way ANOVA with repeated measures, revealed a significant difference among these resources ($\chi^2$ = 192.06, $p < .001$). Post-hoc pairwise comparisons using the Wilcoxon signed rank test, a non-parametric alternative to the paired t-test, showed that participants were more concerned about recorded audio (M = 4.97, SD = 1.80) than GPS location information (M = 3.89, SD = 1.97) (Z = -10.292, $p < .001$) and driving video without traffic violation (M = 3.56, SD = 1.87) (Z = 11.291, $p < .001$). We compared the concerns between video content with and without containing a driver's traffic violation. A non-parametric Wilcoxon signed rank test indicated that respondents were significantly more concerned with driving videos with traffic violation (M = 4.50, SD = 3.56) than with driving videos without traffic violation (M = 3.56, SD = 1.87) ($p < .001$). When examining persons who are being recorded, our participants expressed significant concerns. We compared the privacy concerns about driving video without traffic violation, bystanders, and passengers. We found significant differences using a non-parametric Friedman test ($\chi^2$ = 78.48, $p < .001$). Post-hoc pairwise comparisons using the Wilcoxon signed rank test showed significant differences between privacy concerns about bystanders and driving behaviors without traffic violation (Z = -8.222, $p < .001$), and between privacy concerns about passenger identity and driving behaviors without traffic violation (Z = -6.899, $p < .001$). Respondents were significantly more concerned about pas-

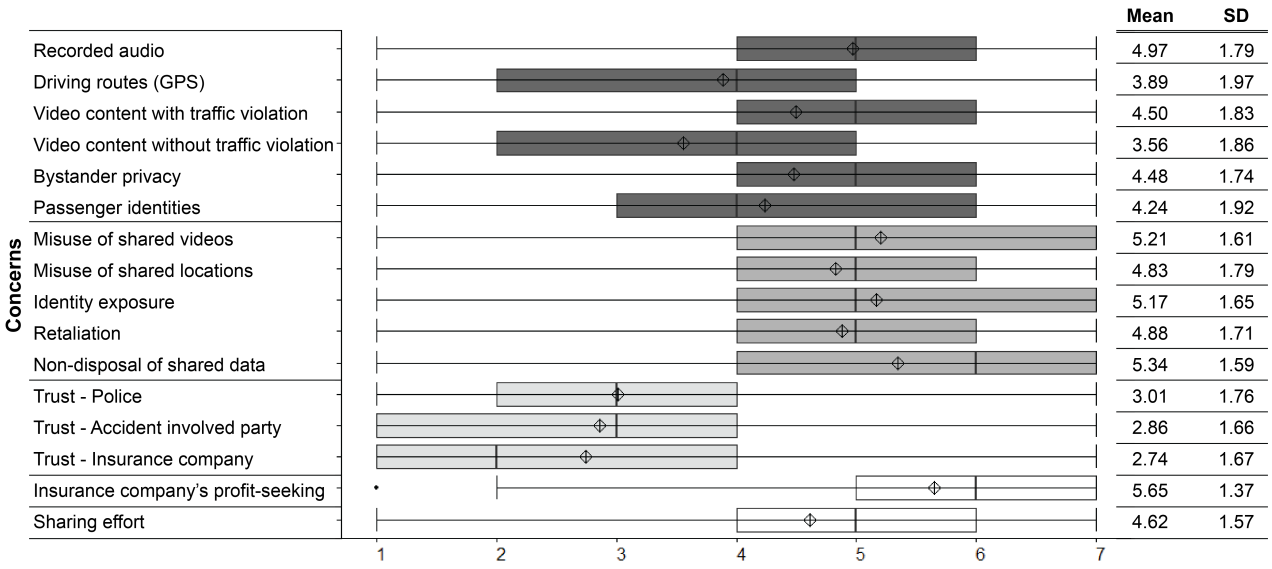


**Figure 2. Level of concern in a 7-point Likert scale (privacy sensitivity items in black, data management concern items in dark grey, and trust in light grey)**

senger identity (M = 4.24, SD = 1.93) and bystander privacy (M = 4.48, SD = 1.74) than driving behaviors without traffic violation (M = 3.56, SD = 1.87).

*Data Management Concerns*: In general, participants had serious concerns about data management, i.e., misuse, identity exposure, and disposal. When comparing misuse of video and location, a Wilcoxon signed rank test result showed a significant difference (Z = -6.351, $p < .001$). This result is consistent with privacy sensitivity concerns as shown above. Overall, our participants had similar level of privacy concerns about misuse, identity exposure, and disposal. Although only a small number of respondents expressed their concerns on retaliation in Study 1, the results showed that our participants had quite serious concerns on this matter (M = 4.88, SD = 1.71).

*Requester's Trustworthiness Concerns*: We asked the participants to rate the level of trustworthiness for managing personal information of shared dashcam videos. Similar to Study 1, we gave three recipient types: police, those involved in accidents, and insurance company. A non-parametric Friedman test revealed a significant difference ($\chi^2 = 21.312$, $p < .001$). Post-hoc pairwise comparisons using the Wilcoxon signed rank test showed that respondents significantly more trusted the police more (M = 3.01, SD =1.76) than those involved in accidents (M = 2.86, SD = 1.66, $p < .05$) and the insurance company (M = 2.74, SD = 1.67, $p < .001$). However, there was no significant difference between those involved in accidents and the insurance company. As shown in Study 1, these differences are partly due to that fact that people cannot ensure the identity of those involved in accidents. Furthermore, respondents were very concerned about the fact that insurance companies might use the videos to gain their profits (M = 5.65, SD = 1.37). This partly explains why respondents trusted less the insurance companies than the police.

In our survey, we also asked the participants to rate their participation willingness to participate in video sharing activities depending on the organizer types, i.e., the police and non-governmental organizations (NGOs). Respondents answered that NGOs were as trustworthy as the police; their willingness to participate did not significantly differ (p = .589, Cohen's d = .054) (authorities: M = 4.52, SD = 1.73; NGOs: M = 4.61, SD = 1.60). We further asked whether respondents are willing to always share their locations while they are behind the wheel, for timely video footage search. When compared with concern of driving routes (M = 3.89, SD = 1.97), respondents expressed considerable reservations on always sharing their driving routes regardless of the organizer types; i.e., M = 5.50 (SD = 1.64) for the authorities, and M = 5.37 (SD = 1.56) for NGOs.

### *Motive Difference Across Different Privacy Groups*

Ackerman et al. [2] performed a cluster analysis of e-commerce users based on their privacy sensitivity to various information items, thus categorizing the users into three groups, which are similar to Westin's privacy classification, i.e., High and Fundamentalist (those who are extremely concerned about privacy), Medium and Pragmatist (those who are concerned about privacy, but less so than the fundamentalists), and Low and Unconcerned (those who are willing to share with less privacy concerned under almost any condition) [26]. To understand our respondents' motives across privacy concern levels, we ran $k$-means clustering with $k = 3$ to divide them into three privacy groups as in Ackerman et al.[2]. For each user, we calculated a two-dimensional vector of a privacy sensitivity score (i.e., a sum of six items about privacy sensitivity items) and a data management concern score (i.e., a sum of five items about data management concern items) (see Figure 2). Our cluster analysis results were as follows: High and Fundamentalist, n=106 (28.42%); Medium and Pragmatist, n=190 (50.94%); and Low and Unconcerned, n=77 (20.64%) (see Table 4). This distribution is comparable to that of Westin's privacy classification [26]. We analyzed how key motives differ across different

| | Fundamentalist (n = 106) | Pragmatist (n = 190) | Unconcerned (n = 77) |
|---|---|---|---|
| Reciprocal altruism & Social justice | 5.44 (SD = 0.97) | 5.80 (SD = 0.82) | 5.91 (SD = 0.98) |
| Monetary reward | 3.16 (SD = 1.47) | 2.77 (SD = 1.49) | 2.29 (SD = 1.46) |

**Table 4. Mean motive scores across different privacy groups**

privacy groups. One-way ANOVA results showed that there were significant differences in motives across different privacy groups; that is, groups with high privacy concerns had a significantly lower reciprocal altruism and justice score ($F(2, 370) = 9.015$, $p < .001$), and a significantly higher monetary score ($F(2, 370) = 7.618$, $p < .001$). As in [2], we also studied whether there are any demographic and experience differences among the groups with different levels of privacy concerns. However, we found no statistically significant differences in various demographic variables such as gender, age, and car price and in driving experience variables such as dashcam usage period, driving years, and accidents.

## DISCUSSION

Our survey results showed that dashcams were mainly used to collect evidence for traffic-related accidents/incidents. Dashcams were checked to determine whether drivers were involved in or had witnessed an accident. Furthermore, they wanted to check others' dashcams when their dashcam had limited coverage (e.g., requesting side views) or was malfunctioning. We then identified the key sharing motives and analyzed which motives were critical within the motivation frameworks of crowdsourcing [24, 25]. Our statistical analysis revealed two latent factors, i.e., reciprocal altruism/justice and monetary rewards. The reciprocal altruism/justice factor was much more important than the monetary factor. The fact that altruism was important concurs with other social-purpose crowdsourcing campaigns such as web-based proofreading in a library [25]. The major differences were that dashcam sharing tasks lacked skill mastery and fun motives, but the reciprocal motive in the altruism/justice factor was found to be much stronger in our study than that in the other crowdsourcing studies due to the anticipation of mutual exchanges.

Our work is closely related to the prior studies on e-commerce and social networking services [2, 3, 13] that systematically investigated various concerns about video sharing such as privacy sensitivity, data management (e.g., disposal, and personal security), trust issues, and sharing efforts, which are critical for systems design. To our knowledge, recent studies on emerging recording technologies [15, 21, 37], however, lacked a holistic exploration of those concerns, and our work attempts to bridge this gap.

As shown by Sleeper et al. [45], we found that in dashcam video sharing, bystander privacy was important, and traffic violation was a serious barrier. In addition, our quantitative analysis revealed that recorded audio was much more privacy concerning than location and driving behaviors if traffic violation was not included. Respondents had very high privacy concerns about data management such as misuse, identity exposure, security risks, and non-disposal. As shown by Consolvo et al. [13] in the context of location sharing, we found that the recipient type is critical when sharing decisions are made. In particular, our respondents cared about a recipient's identity for trust reasons; i.e., whether the recipient can properly manage data, and fairly use the data without seeking profits. For this reason, the police was preferred to those involved in accidents, followed by insurance companies.

As in Westin's privacy classification [26], we were able to cluster users into three groups, i.e., high and fundamentalist, medium and pragmatist, and low and unconcerned. We found that sharing motives varied across groups with different levels of privacy concerns; that is, the group with higher privacy concerns had a significantly lower reciprocal altruism/justice score but had a higher monetary score than the group with lower privacy concerns. As in prior studies on e-commerce sites [2], we did not find any statistically significant differences on demographic and experience variables (e.g., gender, age, and car price).

The privacy hump hypothesis shows that privacy concerns involving an intrusive technology transition from pessimistic levels to optimistic levels and become stabilized over time [22]. We posit that Korea has reached the optimistic phase, because dashcams are widely deployed (more than 60% of adoption rate as of February 2015 [44]), and video sharing is frequently observed. Thus, our survey studies reflect a stabilized view on the motives and concerns behind dashcam sharing, which provides a useful ground for further studies in this direction.

The generalizability of this work is limited such that additional work on different cultures is necessary. We are currently planning to perform similar studies in those nations with high adoption rates such as Russia, Taiwan, and China. Since altruism and social justice motives are universal [23], we expect that our results could be consistent across different cultures. Another limitation is that our work did not explore detailed contextual situations such as activities that are known to have a significant impact on privacy concerns [21, 45]. A field study with real dashcam users (e.g., via experience sampling or day reconstruction) is required to uncover various contextual factors affecting data sharing.

## DESIGN IMPLICATIONS

Current practices of sharing include displaying onsite banners or posting requests in local online forums and popular web portal sites. Researchers also proposed online sharing services that can facilitate dashcam video sharing by matching requesters and providers [9, 34]; for example, the local authority may set up an accident database, and crowd contributors periodically query this database to check for any matching accidents to upload the video clips [9]. Toward realizing such online sharing services, our main findings have significant implications in the following design dimensions: i.e., encouraging motivation for sharing, supporting privacy preserving tools, dealing with trust and policy issues, and matching between requester and provider.

### Encouraging Motivation for Sharing

Our results showed that reciprocal altruism and social justice motives are much stronger than monetary motives. This implies that when organizing an online campaign for sharing dashcam videos, it is important to frame sharing requests by highlighting reciprocal altruism and social justice aspects. In addition, we can leverage the sense of local community, a feeling that members belong to the community and that it helps members to fulfill their needs [33], or community identification that is stimulated by feelings of collective identities [25]. Social motives can be leveraged with gamification mechanisms such as badges, levels, and points [16]. Awarding badges and levels act as a reward for achievement and social recognition, thereby reinforcing contributive behaviors [39]. Our results showed that such gamification methods would be more effective if social justice is properly framed. For example, we can give highly contributing users good citizen badges. Use of monetary rewards should be carefully considered. According to the literature, monetary rewards typically decrease intrinsic motivation particularly when people perceive rewards as manipulators of their behavior [7]. Monetary rewards can co-exist if people see the rewards as a positive feedback that they are competent (e.g., exceeding others' performance, and achieving goals). For example, a campaign operator (e.g., local police station) can reward a user with a special gift if reporting goal is achieved (say recognizing five times of successful video sharing).

### Supporting Privacy Preserving Tools

Users are positive toward privacy-preserving mechanisms in vehicular environments [45]. Similar to conventional recording technologies [32], however, current dashcams lack privacy preserving tools for video sharing. This should be considered in both recording and reviewing phases. At the time of writing, dashcams only support microphone control during the recording phase. What is worse is that PC-based player software lacks also privacy preserving tools such as clipping relevant parts and removing audio tracks or sensor data. Users are required to use separate video editing software such as Windows Movie Maker for privacy preservation. Since video sharing has been increasingly popular in recent years, dashcams should support these basic features, as well as more advanced options such as geo-fencing and blurring, as alluded in [45].

### Dealing with Trust and Policy Issues

Since recipient trust is critical for video sharing, it is preferable for the police or NGOs to operate online mediation services. When bootstrapping online services, there should be clear written guidelines on data management, possibly by following well-known privacy guidelines such as FIPs (e.g., purpose specification, collection and usage limitation, proper disposal, and reasonable security). The guidelines should properly handle multiple stakeholders such as the police, those involved in an accident, and insurance companies. It would be important to deal with several hindrances to video sharing such as inclusion of traffic violation and lack of privacy-preserving tools. The service provider should carefully examine whether video sharing is legally permitted. In most countries, video sharing is legal as long as it does not infringe on personal privacy. However, its usage is prohibited in Austria and is strongly discouraged in public spaces in Switzerland [4].

### Matching Between Requester and Provider

Matching between requester and provider is critical in online mediation services. To preserve privacy, recent research proposals employed two methods, i.e., server side pushing (pushing requests to all clients) and client side pulling (periodically pulling requests from the server). In both cases, video providers (i.e., mobile clients) locally check whether there is a matching footage and do not reveal any information to the server (or the service provider). In general, pushing incurs significant interruption cost to the users, and thus, it is more preferable to implement pull-based approaches. The polling interval should be properly set based on request urgency and dashcam memory size (to prevent overwriting due to automatic loop recording). However, these approaches come at the cost of lacking knowledge about the existence of matched users. An alternative approach is to proactively report user locations while driving; this allows the provider to easily identify a set of contributors and make personalized upload requests. In general, there are trade-offs between utility and privacy concerns. It is possible to lower privacy concerns with privacy preserving techniques such as *k*-anonymity and geo-fencing [22].

## CONCLUSION

Dashcams are a new and pervasive type of recording device that is surprisingly common in many countries such as Korea, China, and Russia. Furthermore, dashcam video sharing has been very common for accident investigation, social awareness, and entertainment purposes. There is a growing consensus that sharing dashcam videos will greatly extend urban surveillance coverage. Understanding privacy concerns is critical for designing pervasive recording devices and data sharing services. However, this new technology has received little attention in the research communities unlike other emerging wearable and smart home devices such as Google Glass and Dropcam. In this paper, we conducted two survey studies (n=108, n=373) in Korea to systematically investigate the major motives and concerns behind sharing dashcam videos for urban surveillance. Our results showed that reciprocal altruism/social justice motives were much greater than monetary motives. There were various concerns related to dashcam video sharing such as privacy sensitivity of shared data, data management practices, sharing efforts, and requester trust levels. When participants were grouped based on privacy concern levels, significant motive differences were found across groups: i.e., the higher the privacy concerns, the lower is the reciprocal altruism and social justice motive, but the higher is the monetary motive. Our work contributes to the body of scholarship on privacy concerns about emerging technologies. We have shown that our findings have practical design implications for designing dashcam devices and video sharing services such as motivating sharing, supporting privacy preserving tools, dealing with trust and policy issues, and matching between requester and provider.

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