Understanding In-Car Smartphone Usage Pattern with an Un-obfuscated Observation

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Figure 1. The in-car monitoring system we introduced to observe drivers in situ. Through the preliminary research, we could best observe both the external situation and the usage of smartphones when we fix the recorder on the headrest of the driver's seat with a separate stand.

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Abstract
The spread of smartphone has enabled everyone to easily participate in information activities regardless of time and space. The interiors of cars are not an exception to this phenomenon. Many drivers use their smartphone while driving, though it is legally restricted due to safety issues. This research intends to (1) observe the information behaviors of drivers (2) classify their information activities (3) and finally induce design implications. For this purpose, we conducted user research using an in-car monitoring system observing drivers in situ (Figure 1) and a smartphone application usage tracker. After gathering and integrating the data through a multi-coding process, we were able to introduce special categories, "five sessions," explaining a smartphone usage pattern in cars particularly. Moreover, using the drivers' voice recordings, we found out drivers' specific informational needs. The results informed us of four implications that could be used in smart cars or car-related services in the future.

Author Keywords
Driver experience; Smartphone; Information behavior

ACM Classification Keywords
H.5.2. User Interfaces

Introduction

Smartphones allow users to access any kinds of information anytime and anywhere. However, they offer the same services regardless of users' context while they can take advantage of situation-specific information.

One example is while driving. People want to use their smartphone as usual while driving, but they have some trouble using it because of safety concerns. There have been two approaches to this problem: (1) supporting technically and (2) prohibiting legally. However, they are insufficient to solve the problem. Though services like a Bluetooth connection and a voice recognition are available while driving, they cannot fully support users' information needs and don't reflect the distinctiveness or issues of driving context. Also, simply legally prohibiting cannot be a fundamental solution. Rather than unconditionally suppressing drivers' desire for information behavior while driving, providing appropriate ways of satisfying their needs should be the concern instead. In this regard, the driver's distinct information behavior is worth analyzing in peculiar.

We aimed (1) to investigate the information behavior of drivers based on in-vehicle smartphone usages, (2) to classify their information activities, and (3) to induce design implications that would be helpful to smartphone services in cars or new ways of car interactions in the future. Using an in-car video recording system (a black box) and AppCatcher, a smartphone usage tracking application, we observed the participants' smartphone use while driving and gathered data. We conducted repetitive coding and ideation process, classifying the information behaviors of in-vehicle smartphone usages into five "sessions": (1) cycling through, (2) coming up with, (3) active pursuing, (4) deferring, and (5) conversing. Each session has its own distinguished properties, which are summarized in Table 1. We also supplemented the result with "voices of drivers" gathered by users' think-aloud and induced four design implications that could be used in smart cars or vehicle-related smartphone services.

Session	Description	Application	Action	Interaction	Duration
Cycling through (10%)	Habitually turning the smartphone on and drifting aimlessly	MIM, SNS, Menu view	Checking, Browsing	Quick tapping, Scrolling	Short (16s~60s)
Coming up with (9%)	Conducting information behavior by using smartphone as something comes to one's mind	Searching, Capturing and Entertaining app	Searching, Watching, Browsing	Scrolling, Quick tapping, Soft typing	Long (1m~5m)
Active pursuing (18%)	Concentrating on using smartphone for a longer time in order to complete information behaviors related with specific purposes	Searching and Producing app	Searching, Browsing	Scrolling, Quick typing, Soft typing	Long (1m~5m)
Deferring (5%)	Avoiding or postponing a response toward push notification in the smartphone	MIM, SNS, Calling	Checking, None	Scrolling, Quick tapping	Very short
Conversing (56%)	Actively communicating with others by using communication apps such as telephone call, MIM, and SNS	Calling, MIM, SNS	Initiating, Reacting, None	Quick tapping, None, Scrolling, Heavy typing	Long (1m~)

Table 1. Five sessions of smartphone behavior patterns in car

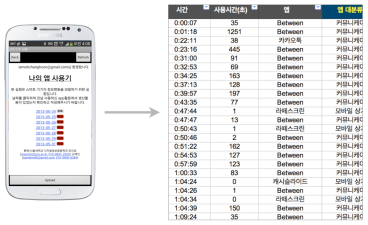

Figure 2. AppCatcher, a Java-based APK application for Android. The program captures their smartphone application log data and automatically transmits the name, starting time, and finishing time of used applications to the server.

Figure 3. Data coding iteration and ideation process.

Related Works

There have been several studies on the use of smart devices. Taylor et al. examined a group of active users and proposed a new framework for understanding mobile Internet motivations and behaviors [4]. Another study revealed that depending on not only the situational context but also the time and resources available, people use diverse and ingenious ways to obtain needed information [3]. Matthews et al. also studied that the use of mobile phones heavily depends on context, particularly users' other devices and the places and situations users encounter [2]. Although those studies found smart device users' motivations and behaviors in detail, they didn't target a specific situation that users face such as while driving.

In relation to driving-specific situation, there was a study about smart device usage behavior in car [1], conducted by Lindqvist et al. The study focused on distracted driving problems, proposing the use of context awareness to implement burden-shifting, time-shifting, and activity-based sharing as a solution. While this research tried to develop a system to solve the problem, we focused on observing real driving situations and categorizing them into meaningful units. We also intended to make an advance in research method by combining quantitative data from the smartphone app log tracker we developed and qualitative data from the video recording system (using a black box) we introduced.

Methodology

We recruited 14 drivers who live in the Seoul metropolitan area and recorded their real daily driving trips for three days. As the apparatus for collecting data, an in-car video recording system for qualitative data (Figure 1) and AppCatcher for quantitative data were used (Figure 2). Through the experiment, we collected 50 analyzable trip data. The total time of the trips was 32h 59m 58s. A variety of driving data were collected—from short data of 5 minutes to long data of 2 hours and 21 minutes (average length is 39m 35s). We gathered two kinds of data: (1) video recording clips and (2) application usage logs. We integrated the data and categorized them into meaningful units by conducting repetitive coding and ideation process (Figure 3).

Five Sessions of Smartphone Usage in Cars

We introduced a concept of "session," a unit of analysis in this research, which is defined as a combination of elements from when a driver picks up a smartphone until he/she puts it down. Each session possesses distinguishing characteristics and has sub-elements such as initiating way of smartphone usage, kind of application, action, interaction, duration, and situation information (Figure 1). The total number of sessions discovered in the collected data was 139. As a result of the multi-coding and ideation analysis, smartphone usage patterns while driving could be organized into five sessions: (1) cycling through (10%), (2) coming up with (9%), (3) active pursuing (18%), (4) conversing (56%), and (5) deferring (5%).

Cycling Through

A cycling through session refers to the case when "a user habitually picks up a smartphone and goes through one thing or another." Most of the users used mobile instant messengers (MIMs) or SNS apps. Some drivers did not utilize any app and just went back and forth on the menu screen itself, which showed the drivers' boredom and habitual usage of smartphones.

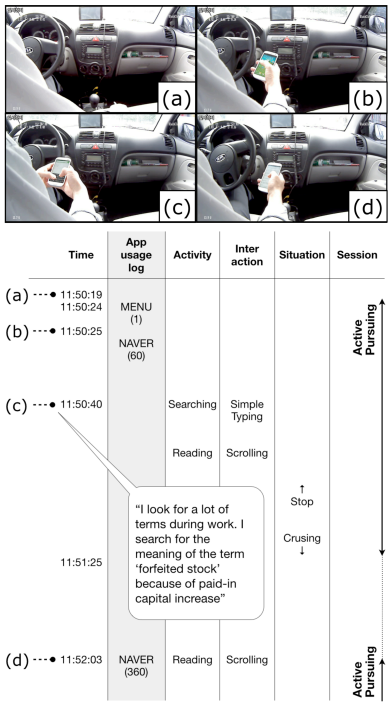

Figure 4. An example of active pursuing session. The session started by picking up a smartphone and using a searching app while the car was stopped. A single app (Naver) was consistently used. A searching activity, which included soft typing with both hands, and a reading activity with scrolling occurred. This activity continued and naturally stopped as the driver concentrated on driving. Also, this session did not end at once, and three further sessions appeared in a discrete way until he grasped full knowledge of the content.

They just habitually checked SNS and MIM apps and browsed post lists. Interactions in this case included slowly scrolling the screen or controlling the depth of the list using a simple button tap. The session usually appears when curising and waiting for signals, and it also appears in stopping and parking situations.

Coming Up With

The coming up with session is the case when "a driver suddenly comes up with an idea and uses a smartphone for information behavior." (1) Searching apps such as Google to resolve the desire for information behaviors, (2) capturing apps such as pictures and notepads to quickly record the thoughts or situations that came across the participants' minds, or (3) other applications such as YouTube to watch a video were used. In this case, actions such as searching, watching (video), and browsing mostly appeared; and a single application was consistently used in one session. Interactions such as scrolling, quick tapping, and soft typing were observed. Regarding the length of time, searching applications were used for relatively long periods (1–5 minutes) while capturing applications only took short lengths of time (30 seconds to 2 minutes). Applications related to music or video clips took 2–3 minutes, and the session usually started with waiting-for-signal situations. There were cases where the purpose of driving influenced the start of this session, such as searching for nearby restaurants.

Active Pursuing

The active pursuing session is defined as "concentrated usage of a smartphone for a long time to achieve an information activity with a specific purpose." In this case, searching apps or producing apps were mostly used. Actions in this session basically included searching, browsing, and careful reading of the selected content or production activities like writing down content. Interactions such as soft typing for entering a search query, scrolling of the list screen, tapping on the selection, and zooming in and out to enlarge content appeared. The duration was usually long, 1–5 minutes. This session did not end after a single session but rather continued with three to four additional sessions and discretely appeared while cruising or stopping (Figure 4).

Conversing

A conversing session happens when the driver "actively communicates with other people using communication apps, like phone calls, MIM, and SNS." It occupied the greatest portion overall (56%). Main applications were phone calls, messengers and SNS. In this case, the main actions were initiating, in which the driver contacted other people first, and reacting, in which the driver answered back other people. Interactions included quick tapping, none (in the case of call), scrolling, and heavy typing. The driver did more typing than ever, to write messages, and quickly tapped through a variety of MIM and SNS apps. Duration was usually long, more than one minute, and this session often appeared in waiting-for-signal situations. When drivers had a fellow rider, this session diminished because of communication with the passenger.

Deferring

A deferring session is a case when the driver "avoids or delays to answer push alarms in the smartphone." Mainly used apps were communication or social network apps, such as MIM, SNS, and calls, which send push alarms to smartphones. In this case, the action most often done by the drivers was checking. Sometimes the participants did not take any action at all. Interactions included scrolling and quick tapping.

The drivers softly touched a button or the screen and ended the session. There were no additional interactions, so the duration of the session was very short. This session especially appeared while (normal) cruising, and high-speed cruising, when practicing an information activity is dangerous.

Voice of Drivers

We requested the participants to do think-aloud, if possible, and carried out a half-open survey after the experiment and organized them like below.

Voice Interaction

Most of the participants expressed their need for voice interaction. P7 said, "I wish my smartphone could type and send what I say." P9 said, "I do not know if such functions exist, but I wish my phone could be changed like 'driving mode' before I start driving. Then, I can use my voice for all the functions." He recognized the popularization of voice-interaction functions, like Siri, and he said he required a driving-specific service. The need of voice interaction was especially related with messages. Feedbacks like "I'd like it to read the message out loud" (P8) and "I'd like a system where I can answer the message by voice, even simply. Also, when message arrives while driving, it would be convenient if there's a service that reads it out loud" (P3) showed this.

Habitual Traits

The participants showed habitual traits about smartphone usage during driving. This especially tended to appear before and after driving. This can be divided into (1) setting and (2) dealing with backlogs. First, about setting, P10 answered, "I leave after I start the car and choose the music," while P2 extraordinarily turned on his wireless Internet receiver and the network of a tablet PC. P4 connected his smartphone to an audio and turned on the radio or music of his smartphone. P6 said, "Before I drive to work, I check the messages or SNS alarms that are piled up from the night before to the morning . . . and I answer to KakaoTalk messages after I finish driving." This shows that he has catching-up desires about things before driving.

Modality

Also, there were a variety of needs for additional interface that can facilitate information activities. P1 said, "it's very inconvenient because I need my hands for both driving and using the smartphone. I wish there were something that can control my smartphone on the steering wheel. And I wish I can get my calls easily like folder phones," which shows the need for a sort of shortcut that gives quick access to any functions. Also, P14 wanted complementary means for smartphone screens such as "I wish that the windshield can show the screen" and "I want a 'driving mode' in the phone in which the letters get bigger."

Safety

The participants often mentioned safety issues. P7 said, "When the car is running, I usually hold back the usage of smartphone. If I should, I slowly start the apps when it's safe." This shows the restraint of information activities using smartphones because of safety problems. Safety also changes the forms of smartphone usage. Some participants checked their phone in a tilted way. P3 said, "I look at my smartphone in one hand in a glimpse. And while driving, I look at the road ahead and glimpse at my smartphone, placing it in the middle of my wheel." Whenever it was safe, drivers always attempted to practice information activities.

Design Implications

Based on both the five sessions and the voices of users, we induced four implications in terms of product design in the future.

1. Providing relevant update at an appropriate time
Updating pending information when the drivers are stopping at a red light could be considered.

2. Communicating selectively and integrally
Instead of presenting the entire text in a small screen, it is better to provide selective texts in order to effectively convey the information to the drivers.

3. Introducing new interaction that does not hamper attention and safety
For safe driving, drivers should not be allowed to read texts directly on the small screen and a simple intuitive interaction like using voice or additional controllers should be provided.

4. Capturing immediate thoughts
The system should provide a shortcut to immediately record whatever passes through a driver's mind.

Conclusion and Future Work

The contributions of this study to the HCI area can be summarized into three parts: (1) observing "real" information behavior regarding in-vehicle smartphone uses and focusing on investigating drivers' information behaviors in situ and (2) introducing the concept of "session," the category of information behavior that was identified through repetitive coding and ideation processes, which explains in-vehicle information behaviors comprehensively. (3) In addition, using the think-aloud protocol and a post hoc survey, we also gathered "voices of drivers," identifying four characteristics, and the results informed us of valuable design implications. We hope that the results of this study would provide a reference for designing smart devices in cars or smart car interfaces.

The limitation of this study is the result is insufficient to cover every detail of drivers' smartphone usage such as game and music. In the near future, we plan to conduct a larger volume of research to provide a more detailed explanation regarding the information behaviors of drivers and make a comparative study between drivers and pedestrians. We are studying the participants' reviews about our research methods and preparing the next version of AppCatcher, more precisely tracking not just smartphone usage logs but also their location information.

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