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The Influence of Smart Car Technologies on Drivers' Perceived Control and Attachment

So-Eun Lee^a, Seongcheol Kim^b

Abstract

Connected to various media technologies such as smart phones or navigation systems, automobiles today are transforming into so-called 'smart cars'. Smart cars are not just mechanical devices, but information media systems. The smart car is a prosthesis that assists the driver, enhancing the original function of the car, and provides a new place environment to the driver by composing a hybrid space where information space and actual space are fused. This article focuses on the fact that smart cars have all the media, functional, and spatial attributes. It is important to understand what smart car technologies are currently used and utilized by people, and how they affect drivers' perception. To examine the issue, an online survey of 340 drivers was conducted, with a focus on perceived control and attachment, as well as on the possession and the use of 14 smart car technologies. The results of hierarchical regression analysis reveal that the possession of smart car technologies influences on drivers' perception of control and attachment, regardless of the actual use. Based on the results, this article discusses the implications and the limitations, together with the practical suggestion for smart car system construction.

Keywords: Smart car, use of media technologies, hybrid space, control, attachment

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1. Introduction

As a new growth engine of future industry, ‘smart car’ has emerged at the center of social enthusiasm. Smart car is “an automobile that combines electric, electronic and communication technologies to provide a high level of safety and convenience” (FKII, 2016, p. 18). In a broader sense, it refers to the whole development process of automobile that evolves environmentally friendly and improves safety by collecting information of in-vehicle devices as well as surroundings in real time to add convenience to the drivers.¹

It is expected that smart cars will rapidly develop to lead the ICT market as well as the automobile industry. Gartner (2016) has predicted that in 2020 one of the world’s five vehicles would be smart cars. According to BI Intelligence, smart car is expected to account for 75 percent of global vehicle production in 2020 (Meola, 2016). Reflecting this prospect, the Consumer Electronics Show(CES) for the recent two years was close to the ‘Motor Show’, where not only companies in the automobile industry but also those in the ICT, software and communication industries eagerly participated in demonstrating their cutting-edge smart car technologies. Governments around the world are also expanding support, regarding smart cars as a key driver of future growth (Lee, 2013).

There is no doubt that smart car is becoming a social flow. The problem is that academic discourse is heavily concentrated on technical principles and marketing strategies compared to social interests. Smart car is not just a mechanical device but an information media system. It

¹ The term ‘smart car’ is mainly used in Korea as the almost same word as ‘Connected Car’, ‘Intelligent Automobile’, ‘Self-Driving Car’ or ‘Autonomous Vehicles’. Smart car, however, can be understood as an umbrella concept covering related expressions, since it refers to a series of processes that provide the safety and convenience to the drivers through the intelligence of the vehicle (Yoon, 2016). In comparison, ‘Connected Car’ has a narrower meaning that emphasizes the status of being connected to the network. Smart car is more commonly used in everyday life compared to ‘Intelligent Automobile’, seeing the manner that the former was primarily searched in Google while the latter was so in Google Scholar (Rhiu et al., 2015). ‘Self-Driving Car’ or ‘Autonomous Vehicles’ are more focused on the automation of the driving, hence correspond to the future direction that the smart car ultimately pursues. Meanwhile, there are cases where the technologies that constitute the smart car are separately referred to. In-Vehicle Infotainment (IVI) system or Advanced Driver Assist System (ADAS) are examples. This article focuses on the influence of the possession and the use of smart car technologies, rather than smart car itself. For this reason, each of the technology applied to the vehicles to implement a car is called ‘smart car technology’, while an implemented vehicle as a whole is called a ‘smart car’ or a ‘smart car system’.

interacts not only with drivers but also with the environment including other vehicles, objects, roads or pedestrians, which can cause a great ripple effect at the social level. It is thus necessary to approach to smart cars from a wider perspective. Beyond looking at smart cars as new technologies or products, it is required to pay attention to the everyday-relevant aspects of smart cars to deliberate on social and cultural meanings of them.

Therefore, this article regards cars as a daily living space and focuses on the fact that the introduction of ICT technologies has made this space a media platform or “hybrid space” (de Souza e Silva, 2006). This paper specifically explores whether driver’s perception is changing, influenced by the infiltration of technologies. To do this, we first investigate the possession and the use of smart car technologies through a survey of real drivers, and then analyze whether the driver’s perception of control and attachment are affected by the possession and the use. What smart car technologies do people currently have and use? Will drivers feel more control over the car as the smart car system is configured? Will they feel more attached to the car after having various in-vehicle technologies? Does the influence vary depending on the number of technologies deployed in the vehicle or the degree of utilization? Answering the questions, this article tries to diagnose the current transitional situation rather than to presume the unknown future. This is significant because the majority of studies are now focused on predicting future market sizes or explaining technologies that can be introduced. We intend to convey practical implications of smart car system configuration by answering the questions. In doing so, we will ultimately be able to discuss the meaning of the infiltration of media technology into everyday life.

2. Theoretical background and research questions

2.1. Smart car as a media system

The meaning of automobiles is changing along with technological advances. If the automobile was a ‘mechanical device’ in the past, it has become a ‘media system’ in combination with various electric, electronic, and communication technologies. Automobiles today exist as a kind of residential space that provides drivers with comfort and rest. Also, they

are becoming like a multitasking communication platform and a command center for the overall manipulation of telephones, television, and the Internet (Featherstone, 2004). Dant (2004) states that today's cars are combined with drivers to become a 'assemblage'. He says the automobile is becoming a "driver-car" that is characterized by its relationship with the driver, and it is necessary to view the "driver-car" as a social entity in terms of causing new social behavior. In modern society, it is important to understand the interaction between humans and automobiles, including the driving process as well as the 'affordance' that operates in this process, and the embodied relationship with the vehicle, Dant (2004) claims.

It is the smart car technologies that play a key role in building the "driver-car" that Dant (2004) emphasizes. These technologies 'infiltrate' into the vehicle, delivering media representations such as video or audio, and coordinating the driver's behavior. Smart car technologies "mediate" the driver and the car, and various information in the external environment is linked to this "driver-car". The nature of the "driver-car" depends on which technology or information is associated with it. For example, when the infotainment technology is widely utilized, a "driver-car" is likely to be more information-sensitive, while it becomes more driving-friendly when the driving assistance device is mainly used. As a kind of 'assemblage media', the smart car is defined by the technology introduced in the vehicle, and more importantly, by what the driver actually uses.

However, most of the previous studies on smart cars concentrated on predicting the future market size or the technologies that can be introduced. Or, most studies only have calculated the sales status of the individual technologies. It is not clearly identified what kind of media space is constructed for the driver, and whether there is a difference in utilization depending on the demographic group. Therefore, this study sets up the following research question.

RQ1. What smart car technologies do people currently have and use? Are there differences between demographic characteristics?

2.2. Smart car as a functional prosthesis

In what ways does the smart car technology affect the driver? To approach to the question, we pay attention to the fact that cars are a kind of prosthesis that assists the driver. The introduction of smart car technology is helping to automate and enhance functional aspects of the cars. If recalling McLuhan (1964), automobiles are an extension of the foot and have the instrumental qualities of an ambulatory system that aids man in his walking. Humans manipulate, control and tame cars (Lee et al., 2016). The more the driver becomes familiar with vehicle functions, the more likely (s)he feels control over the vehicle. Smart cars can be described as ‘advanced prostheses’ that automate vehicle response and reduce driver’s cognitive effort. We thus investigate whether ‘perceived control’ changes as the automobile evolves into ‘more advanced prosthesis’ with the introduction of smart car technology.

Perceived control refers to “people’s perception of the ease or difficulty of performing the behavior of interest” (Ajzen, 1991, p. 183) or “subjective degree of control over performance of the behavior itself” (Ajzen, 2002, p. 668). The concept was mainly used as a predictor of behavior intention in the theory of planned behavior (Ajzen, 1991), and later used as a leading variable of perceived ease of use and perceived usefulness in the development of the Technology Acceptance Model (TAM) (Agarwal & Prasad, 1999; Gefen, Karahanna & Straub, 2003; Venkatesh, 2000). It is also closely related to the self-efficacy in the social learning theory (Bandura, 1997), and depending on what the subject of control is, the concept develops into several notions such as time control (Macan, 1994), environment control (Maguire, Burgess & O’Keefe, 1998) or media control (Compeau & Higgins, 1995). According to what the source of control is, it is divided into internal and external control (Rotter, 1966).

While the previous studies have dealt with perceived control as a predictor of the adoption and use of media, this study examines it as one of the ‘effects’ of smart car technology. This is because the extent to which a driver feels easy or difficult to perform the function of driving will vary depending on the degree of possession and use of smart car technology.

Recent studies show contradictory results on this issue. For example, Alliani and colleagues (Alliani et al., 2016) have found that parking becomes easier under a smart parking system based on vehicle-to-vehicle communication. Birrell & Fowkes (2014) have verified that the use of smartphone applications during vehicle operation is very informative rather than visually distracting. It has also been shown that context-based or simulation technologies such as head-

up displays and in-vehicle information systems contribute to driving space recognition and information acceptance (Doshi, Cheng & Trivedi, 2009; Kim & Dey, 2009). These studies support that smart car technology helps drivers feel easier to control the vehicle than before. As many advertisements claim, smart car technologies enhance driving pleasure and control by reducing the driver's cognitive effort in manipulating the vehicle.

On the other hand, there are also studies that show that smart car technology does not affect or even reduce control. Rajaonah et al. (2008) conducted an experimental study, but did not reveal the relationship between driving assistance and the driver's confidence. Larsson (2012) shows the more the driver uses ADAS, the more (s)he perceives the limits of the device itself. Stanton and Young (2005) also explain that vehicle automation can help in situational awareness, but does not affect control over the vehicle. In a situation where the smart car technology is not yet complete and the driver is not assimilated enough, the smart car technology may cause a burden of cognitive overload or hyper-connection. The fatigue of the operation of the media device may interfere with the control of the vehicle. Featherstone (2004) emphasizes the emergence of new risks as the degree of dependence on software is increased, mentioning the driver needs to constantly manage various technical devices and information, like an airplane pilot. Haddington & Rauniomaa (2011), Kadry (2016) and Seltzer et al. (2011) also suggest that manipulating a smartphone or a digital device attached to the vehicle during operation increases the accident rate. Concerns about malfunctioning of smart car technology (Bansal, Kockelman & Singh, 2016) can also weaken the sense of control over automobiles.

Seeing the conflicting results, this study investigates the impact of the smart car technology on the driver's perception of control. Comparing to previous researches which focused on the efficacy of 'one' technology in an artificial experimental situation, it would be meaningful to verify the effect of smart car technology in everyday situations with a survey. In addition, it is worthwhile to examine the driver's perception as it may be different from the 'actual' consequence of smart car adoption such as dispersed gaze or increased accident rate. In this article, we define perceived control as the 'awareness of the ability to strategically adjust vehicle functions in a suitable manner', based on Weyer et al. (2015), and examine the variable in the context of everyday situation. Since there are cases where the possession of technology

affects the driver's perceptions regardless of the actual use, the following research question will be explored.

RQ2. Does the possession and use of smart car technology affect the driver's perception of control over the car?

2.3. Smart car as a hybrid space

The second point that this article focuses on is that the automobile is a 'place' rather than a neutral space. A place is formed when a space contains culture, activity occurs, and meaning is given. If space refers to the "surface of the earth with no characteristics and uniqueness" (Augé, 1992/1995, pp. 82-83), place emphasizes the unique status, meaning, and identity given to space through belonging and experience (Lukermann, 1964; Relph, 1976; Tuan, 1977). In modern society, automobiles exist as places which extend personal space reflecting individual identity and preference, rather than being simple transportation means or devices. The automobile is a tool for expressing personality, and it is a symbol that reveals social resources such as identity and power (Gartman, 2004; Gatersleben, 2007). Collin-Lange (2014) describes the driving of a vehicle is the process of territorial expression that approaches its own mobility and space. This process transforms a car space into a meaningful territory and place. The car provides the driver with a privatized space and exists as a place.

The fact that a car is a place which is territorialized by experience means that the car is subject to psychological attachment. Attachment refers to a "strong affectionate bond that binds closely to a loved one" (Bowlby, 1979). It is often used to describe the relationship between people, but can be extended to feelings about objects such as pets (Woodward & Bauer, 2007), brand (Schouten & McAlexander, 1995), or media devices (Kleine & Baker, 2004; Wehmeyer, 2007). A specific place is also a subject of emotional attachment. Many studies have shown that place attachment contributes significantly to the sense of place (Brown & Raymond, 2007; Jorgensen & Stedman, 2006; Kyle, Graefe & Manning, 2005; Raymond, Brown & Weber, 2010; Williams & Vaske, 2003). Place attachment particularly emphasizes the personal experience and emotional ties of a place and the unique meaning formed through it (Shamai, 1991).

An automobile can be considered as a place of expressing and composing the driver's identity, and hence it can be the object of emotional bond, attachment. What is noticeable is that the introduction of smart car technology constitutes a "hybrid space" (de Souza e Silva, 2006)² where the information space and the actual space are fused. Smart car technology changes the place environment experienced by the driver. Recalling that a car has inherent mobility attributes, the car itself becomes like one large mobile media with the introduction of smart car technology that combines mobile space with communication and information space. A driver becomes located in this "hybrid space" as (s)he uses in-vehicle technologies.

So how would this hybridity affect the driver's attachment to a place? Previous research on in-car media, especially car audio, says that the media technology introduced in the car transforms the car into a more private space. Bull (2004) suggests that sound technology constitutes a new way of "residence" in everyday space, especially making a non-substitutable "acoustic listening chamber". Inside the car space, the driver can feel comfort and happiness of his own by immersing himself in the sound. Similarly, Bysterveld (2010) also analyzed the car radio and internal sound design of European cars from the 1920s to the 1990s, and found that the introduction of car audio systems made the car a highly personal, controllable, "sonic bubble". The in-car audio has made the car evolve into "acoustic cocooning" while configuring the sensory privacy. These studies suggest that when the automobile space is personalized by the penetration of the media technology, the driver may feel a stronger sense of attachment.

The problem is that smart car technologies are related not only to the listening media but also to various sensory information. It can cause cracks in bubbles when information about the outside space continuously enters through the infotainment system. In the words of Edward Soja (1999), the space that is newly formed in the cracked place is not the physical space nor the information space, but the 'third space'. The driver oscillates between the place and the information space (Thielmann, 2006), which can lead to confusion of attachment.

² "Hybrid space" is a concept proposed by de Souza e Silva (2006) to explain the networked mobile spaces formed by use of mobile media. Observing that a new space is formed between physical space and digital space along with the mobile media use, she suggests the concept "hybrid space". This space is not the result of technology, but it is materialized in both physical and digital space based on the connectivity as mobility combines with communication.

How will the hybrid space formed by smart car technology affect the attachment to the car as a place that has been built up through long experience and relationships? For the answer, this paper defines affection as ‘emotional bondage to the vehicle’ and sets up the following research question. As in the case of control, the question is applied to the possession and use respectively as expensive smart car technology may make drivers like their cars more, regardless of its actual use.

RQ3. Does the possession and use of smart car technology affect the driver's attachment to the car?

3. Research Methods

3.1. Subjects and Characteristics

For the analysis, an online survey was conducted by a professional survey agency “Marketlink”. The survey was targeted to those who have his own vehicles or have vehicles owned by his family. Participants were sampled from seven major cities in Korea based on gender and age proportional quota. The survey was conducted from April 11 to April 14, 2017. After excluding the respondents who do not have a vehicle or seldom drive the car, a total 340 drivers aged 19 to 59 were included in the final analysis. When having more than two automobiles, participants were asked to answer based on the car (s)he has driven the most. The demographic characteristics of the participants are shown in the table below.

Table 1. Respondent profile.

Category		Frequency	Percentage	Category	Frequency	Percentage	
Total		340	100.0	Education	High school	31	9.1
					Undergraduate	14	4.1
Gender	Male	174	51.2		Univ. graduate	258	75.9
	Female	166	48.8		Graduate school	37	10.9
Age	19~29	78	22.9	Household Income (million Won per month)	100 or less	0	0.0
	30~39	83	24.4		100~200	13	3.8
	40~49	84	24.7		200~300	49	14.4
	50~59	95	27.9		300~400	52	15.3
Region	Seoul	150	44.1		400~500	60	17.6
	Busan	50	14.7		500~600	49	14.4
	Daegu	38	11.2		600~700	38	11.2
	Incheon	40	11.8	700~800	28	8.2	
	Gwangju	22	6.5	800~900	16	4.7	
	Deajun	24	7.1	900~1000	16	4.7	
	Ulsan	16	4.7	1000 or more	19	5.6	

In addition to demographic variables, personal characteristics such as driving experience and factors related to the attributes of the car were also collected. The average driving experience of respondents was about 11 years and 6 months ($M = 138.61$, $SD = 103.87$, $Range = 1 \sim 425$ months). 243 (71.5%) respondents were the owners of his own vehicle and the remaining 97 (28.5%) were using cars owned by other family members. Respondents have been using their cars for an average of 6.21 years ($SD = 4.10$, $Range = 1 \sim 21$ years). 88 of them are driving daily (25.9%) and 15 (4.5%) drives less than two days per month. The average daily driving time was approximately 1 hour 56 minutes ($M = 115.99$ minutes, $SD = 81.19$, $Range = 20 \sim 840$ minutes). 329 (95.3%) respondents were using domestic cars, 16 (4.7%) were using foreign ones. 61 people (17.9%) bought a used car, while 279 (82.1%) bought a

new one. The average price of the vehicle at the time of purchase was 23.56 million Won (approximately 23,000 dollar) (SD = 13.27 million, Range = 0 ~ 89 million Won).

3.2. Measurement of Variables

3.2.1. Possession and use of smart car technology

Though several organizations have proposed a classification for smart car technologies, it is techno-centric, and not driver-friendly. Even if the technical principle is the same, there are cases where the technology is selected and perceived different by the driver, and there are cases that drivers do not easily recognize though they are using the very technology. Therefore, we restructured smart car technologies into 14 lists based on safety, convenience and sensibility, which has been suggested by Baek & Jang (2016) and Bae (2014).

Safety technology refers to technologies that enhance the drivers' safety by using sensors or constructing a risk prevention system by fusing information between the vehicle and the road or the vehicle and the vehicle. Convenience technologies include vehicle support services such as remote control, communication systems such as mirror links, and information devices such as navigation. Sensibility technology is to enhance the driver's emotional satisfaction through human-friendly interfaces. Speech recognition system or augmented reality display are examples. The specific list and the meaning of each technology are shown in Table 2. In the questionnaire, a brief description of the technology was presented along with the photograph, and then the user was asked whether the technology was applied to his vehicle in operation. When responding 'Yes', it was measured as the possession of a specific smart car technology. By adding them, we calculated the total number of smart car technology possession by individual.

The use of smart car technology was measured by the number of use, usage frequency, utilization rate, ease of use, and satisfaction. The respondents who answered that they had smart car technology were asked about how often they used the technology (frequency), whether the technology was easy to use (ease of use), if they were satisfied with the technology (satisfaction). Utilization rate was calculated by dividing the number of use by the number of possession by individual.

Table 2. Configuration of smart car technology

Category	Smart car technology	Meaning / Exmaples
Safety	Front / Back / Side monitoring	Technology that senses front, rear, and side by sensor attached to vehicle and camera to generate warning sound when dangerous e.g. Rear-view camera, Around view, Lane keeping assist
	Collision Prevention	Technology that Automatically controls the driving and steering of the vehicle to prevent accidents when the risk of collision with pedestrians or other vehicles is detected e.g. Blind spot detection, Automatic emergency braking
	Driver Injury Reduction	Technology to protect driver by automatically adjusting position of seat belt, airbag, etc. in case of danger such as sudden braking or collision e.g. Pre-safe seatbelt, Intelligent airbag
	Driver's Condition Observation	Technology that detects the condition of driver's drowsiness through the sensor recognition or operation pattern analysis e.g. Driver attention alert
	Car black box (video recorder)	Technology to save driving and parking images and to record accident data before and after accident
	Intelligent Headlamp	Technology that supports night vision by optimally injecting headlights at tunnels, curves, and intersections, or automatically adjusting headlights to match the light of vehicles e.g. Automatic headlights, Smart high beam
Convenience	Interior Environment Optimization	Technology that converts and maintains indoor environment (seat, temperature, humidity, etc.) to the optimal state by recognizing driver's body size and driving habit e.g. Smart posture caring system, Demand control ventilation
	Automatic Driving	Technology to run on its own without driver's operation through various sensors and automatic control system e.g. Smart cruise control, Highway driving assist
	Automatic Parking	Technology that recognizes the available parking space through a situation-aware sensor and automatically parks or assists parking
	Smart Device Interlocking	Technology that connects media such as smart phones and tablet PCs with terminals in vehicles e.g. Mirror Link

	Telematics*	Technology that can remotely diagnose a vehicle through a wireless network installed in the vehicle, deliver voice / e-mail messages, and retrieve various information such as video through the Internet e.g. Smart office
	Real-Time Navigation**	Technology that provides various information such as GPS information and road situation in real time using the device attached to the vehicle or a separate device such as a smart phone
Sensibility	Speech Recognition	Technology for starting up or manipulating in-vehicle devices and information through voice
	AR Display	Technology to superimpose and synthesize information such as text and graphics on the car windshield in real time e.g. Head-Up Display(HUD)

* Telematics refers to technology connected to the network through the vehicle's own functions, which is different from Smart Device Interlocking. This was noticed to respondents.

** In a broad term, navigation is included in the telematics system. It is configured as a separate item, however, considering that it is widely used as an external function through a smart phone these days.

3.2.2. Perceived control

In order to measure the perceived control, the question list was constructed based on the study of Compeau & Higgins (1995), Venkatesh (2000) and Weyer et al. (2015). Compeau and Higgins used a variable called “computer self-efficacy” by applying the TAM, and Venkatesh added a perception of external control to reconstruct the sub-elements of perceived control. Weyer and colleagues presented measures of perceived control in the context of using smart cars. The purpose of this study is to understand the driver’s perception of the functional attributes of a car. Therefore, it is necessary to measure the self-efficacy and the control over the subject rather than the achievement through the recognition or control of the social environment. The proper items were selected and modified to form the measurement items. Of the original six items, one with low reliability was excluded, and a total of five items were used for the analysis. The questions are ‘My car is easy to drive’, ‘I can control my car as easily as I want’, ‘I have the knowledge to handle my car’, ‘I can easily drive other vehicles besides my car’, and ‘If I have a problem with my car, I can easily identify and fix it’. Each item was

measured according to five point Likert scale ranging from ‘Strongly Disagree’=1 to ‘Strongly Agree’=5 ($M = 3.476$, $SD = .572$, and $\alpha = .768$).

3.2.3. Attachment

Attachment measurement items were constructed with reference to previous studies on attachment to places (Choi & Kim, 2011; Choi & Lim, 2005; Jorgensen & Stedman, 2006; Kyle et al., 2005; Raymond et al., 2010; Williams & Vaske, 2003). These studies have explored and measured place attachment based on detailed concepts such as ‘place identity’, ‘place dependence’, and ‘place rootedness’.³ Among these three sub-concepts, ‘place rootedness’ is not suitable for this study that is interested in the influence of the introduction of smart car technology. Therefore, six items were extracted by selecting items commonly used by previous questionnaires for ‘place identity’ and ‘place dependence’. They are ‘My car says a lot about who I am’, ‘My car means a lot to me’, ‘I feel my car is a part of me’, ‘I feel happiest when I am in my car’, ‘I will miss my car when I change it’, and ‘My car is my favorite place to be’. The questions were measured according to five point Likert scale ranging from ‘Strongly Disagree’=1 to ‘Strongly Agree’=5 ($M = 3.247$, $SD = .691$, $\alpha = .867$).

3.3. Analysis Method

T-test and ANOVA were conducted to detect the group difference, and hierarchical regression analysis was performed with main variables. In the regression analysis, the independent variables were composed of the individual factor, the vehicle factor and the smart car technology factor. The smart car technology factor is composed of the number of smart car technology possession, usage rate, frequency, ease of use, and satisfaction. The number of use was excluded due to multi-collinearity. Individual factors consisted of gender, age, region,

³ Although the details are different according to the research, the place identity normally means a psychological consensus or homogeneity with a place in symbolic and emotional terms. Place dependence implies an attachment to the functional characteristics of the place. Place rootedness is a sense of root consciousness or cultural belonging to a place. It is known that it occurs naturally when a person inhabits in one place for a long time.

education, income, and driving experience. The factors of the vehicle were ownership, co-using condition, duration of car use (month), frequency of car use per week (consisting of 10 points from 'almost none' to 'daily'), driving time per day (minute), domestic / foreign car, new / used car at the time of purchase, and the price of car at the time of purchase. SPSS 24.0 was used for the analysis.

4. Research Results

4.1. Results of Descriptive Analysis

4.1.1. Possession and use of each smart car technology

According to the analysis, real-time navigation (91.5%) was ranked as the most possessed technology, followed by black box (78.8%), front / rear and side monitoring (44.4%), smart device interlocking (43.8%), collision prevention (31.8%) and driver injury reduction (27.6%), and AR display (5.6%). Except for navigation, safety technology has been popularized the most.

The number of people using the technology showed a similar order to that of technology holders. The difference between the number of people possessing and using each technology was about 1%, which implies that most of the technology was used by the driver. The black box was found to be the most frequently used ($M = 4.19$), followed by front / rear and side monitoring ($M = 3.8$), interior environment optimization ($M = 3.8$), collision prevention ($M = 3.7$), and intelligent headlamp ($M = 3.6$). The frequency of use of automatic driving ($M = 2.74$) and speech recognition ($M = 2.77$) were relatively low.

The technologies that are highly utilized have been recognized positively by drivers in terms of ease of use and satisfaction. Most of the technologies have higher score for satisfaction than ease of use, except for black box, real-time navigation, automatic driving and speech recognition. It is interpreted that black box or navigation is a technology that has been used for a relatively long time by a lot of people, and hence recognized as easy to use.

Table 3. Descriptive statistics by each smart car technology

Category	Smart car technology	Number of possession		Number of use		Frequency of use		Ease of use		Satisfaction	
		No.	%	No.	%	M	SD	M	SD	M	SD
Safety	Front / Back / Side Monitoring	151	44.4	151	44.4	3.84	.967	3.89	.753	3.96	.747
	Collision Prevention	108	31.8	105	30.9	3.73	1.001	3.87	.833	3.89	.777
	Driver Injury Reduction	94	27.6	70	20.6	2.82	1.352	3.34	.945	3.69	.776
	Driver's Condition Observation	27	7.9	23	6.8	3.59	.844	3.67	.832	3.81	.834
	Car Black Box	268	78.8	266	78.2	4.19	.980	4.07	.775	4.03	.741
	Intelligent Headlamp	82	24.1	79	23.2	3.66	1.068	3.87	.782	4.01	.745
Convenience	Interior Environment Optimization	80	23.5	74	21.8	3.84	.849	4.01	.755	3.93	.808
	Automatic Driving	50	14.7	41	12.1	2.74	1.259	3.54	.862	3.50	.863
	Automatic Parking	33	9.7	29	8.5	3.09	1.208	3.55	.905	3.76	.902
	Smart Device Interlocking	149	43.8	141	41.5	3.46	1.177	3.62	.890	3.77	.857
	Telematics	28	8.2	27	7.9	3.43	1.069	3.71	.810	3.71	.810
	Real-Time Navigation	311	91.5	310	91.2	4.01	1.035	4.00	.753	3.97	.832
Sensibility	Speech Recognition	73	21.5	57	16.8	2.77	1.242	3.26	.817	3.12	.985
	AR Display	19	5.6	18	5.3	3.42	1.216	3.53	1.219	3.79	1.084

4.1.2. Differences in smart car technology possession and use by group

Examining the status of smart car technology usage by individual, the average number of smart car technologies possessed by a driver was 4.33 (SD = 2.927, Range = 0 ~ 14). The average number of use was 4.12 (SD = 2.881, Range = 0 ~ 14), which was similar to the number of possession. This is also revealed in the utilization rate (M = 0.95, SD = .134). Drivers recognize that smart car technology is used quite often (M = 3.62, SD = .818). The ease of use (M = 3.76, SD = .611) and satisfaction (M = 3.80, SD = .606) were found to be positively evaluated by drivers.

Table 4 shows the results of the differences of the variables by demographic groups. There was no statistically significant difference in the utilization rate and the satisfaction level among the groups, while the number of possession and the number of use showed difference by demographic groups except for gender. This means that even though the absolute number of possession of smart car technology is different, the degree to which the technology is used and the degree of satisfaction with it are similar among social groups. As can be easily predicted, it was found that male drivers perceived smart car technology easier than females. Teenagers and highly educated drivers showed higher score in the ease of use than drivers aged over fifty and with high school education respectively.

Table 4. Results of group comparison

Category		Number of possession		Number of use		Utilization rate		Frequency of use		Ease of use		Satisfaction	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Gender	Male	4.37	2.886	4.16	2.846	0.95	.133	3.66	.855	3.85	.646	3.83	.636
	Female	4.30	2.977	4.08	2.926	0.95	.134	3.58	.778	3.67	.559	3.77	.572
	t	.228		.226		.233		.904		2.664**		.994	
Age	19~29	4.49	2.490	4.35	2.491	0.96	.113	3.82	.743	3.92	.680	3.92	.649
	30~39	4.96	2.852	4.63	2.810	0.93	.154	3.62	.798	3.78	.582	3.78	.571
	40~49	4.48	3.374	4.29	3.317	0.96	.106	3.73	.695	3.76	.604	3.78	.652
	50~59	3.53	2.759	3.35	2.712	0.95	.151	3.35	.929	3.62	.554	3.74	.550
	F	3.930**		3.459*		.885		5.620**		3.527*		1.480	
Region	Seoul	4.97	3.278	4.75	3.285	0.94	.157	3.63	.803	3.81	.537	3.82	.524
	Other cities	3.83	2.514	3.62	2.411	0.96	.112	3.61	.832	3.73	.663	3.79	.665
	t	3.505***		3.536***		-0.831		.184		1.222		.547	
Education	High school	3.13	2.109	3.03	2.137	0.96	.115	3.45	.894	3.43	.633	3.72	.679
	Undergraduate or higher	4.45	2.972	4.23	2.926	0.95	.135	3.64	.810	3.80	.600	3.81	.599
	t	-3.191**		-2.219*		.614		-1.179		-3.184**		-0.782	

Income	300 or less	4.21	2.835	4.05	2.790	0.96	.097	3.72	.764	3.86	.589	3.87	.623
	300~600	3.86	2.444	3.63	2.358	0.95	.139	3.57	.846	3.71	.612	3.78	.598
	600~900	4.27	2.923	4.00	2.841	0.93	.166	3.51	.845	3.73	.623	3.73	.618
	900 or more	6.89	3.833	6.80	3.849	0.99	.051	3.88	.664	3.91	.599	3.95	.575
	F	11.287***	12.965***	1.612	2.112	1.580	1.428						
Total		4.33	2.927	4.12	2.881	0.95	.134	3.62	.818	3.76	.611	3.80	.606

*p<.05, **p<.01, ***p<.001

4.2. Results of Hierarchical Regression Analysis

4.2.1. Perceived control

Table 5 presents the results of hierarchical regression analysis on perceived control. In Model 1, where only demographic attributes were applied, only gender influence was confirmed ($\beta = 0.302$, $p < .001$). In model 2, which added the variable of driving experience, gender ($\beta=0.214$, $p<.001$), age ($\beta = -0.169$, $p < .05$) and driving experience ($\beta = 0.337$, $p < .001$) were found to have significant influence on drivers' perceived control.

Next to personal factors, we added the vehicle factors in Models 3 and 4. In Model 3, where driver-related variables were applied, the influence of gender ($\beta = 0.212$, $p < .001$) and driving experience ($\beta = 0.217$, $p < .01$) were confirmed. According to Model 3, the drivers perceived more control over the vehicle when they drove the car more frequently ($\beta=0.264$, $p<.001$) and longer ($\beta=0.133$, $p<.01$), under the condition that the other family members did not use the car ($\beta=0.142$, $p<.05$). In Model 4, in which the attributes of the vehicle itself were added, the influence of the car price ($\beta = 0.082$, $p < .05$) was confirmed while the effects of the variables verified in Model 3 were still maintained.

As a result of examining the influence of the smart car technology factors on the perception of control, along with gender ($\beta = 0.205$, $p < .001$), education ($\beta = -0.103$, $p < .05$), ownership ($\beta = -0.123$, $p < .05$), co-using status ($\beta=0.130$, $p<.05$), frequency of driving ($\beta = 0.252$, $p < .001$), and car price ($\beta=0.040$, $p<.05$), the effects of the number of possession ($\beta=0.204$, $p<.001$) as well as frequency of use ($\beta=0.191$, $p<.001$) were significantly verified. While several variables

changed to be insignificant, driving experience ($\beta = 0.155$, $p < .05$) and satisfaction ($\beta = 0.179$, $p < .05$) were found to have a statistically significant effect on control in Model 5.

In sum, the influence of gender, education, driving experience, frequency of driving per week, and car price are generally confirmed, and it is necessary to pay attention to the influences of the number of possession, frequency of use, and satisfaction among smart car technology factors. It is not surprising to see that male drivers with more driving experience have a higher sense of control. However, the result that high-educated drivers have lower control of the vehicle is a contrary to common sense, so a more detailed approach is needed in the future. In the final model, the variable with the highest regression coefficient was the frequency of driving per week, whereas the average daily driving time had no significant effect on the control. This implies that the more often they drive, the more closely they are in control of the vehicle, regardless of how long they drive. In addition, the results show that the frequency of driving is more influential than the frequency of using smart car technologies.

What is interesting is the result of the analysis of smart car technology factors. The influence of the utilization rate is not verified, but the influence of the number of technology possession is significant in both models 5 and 6. This indicates that if the smart car technology is applied to the vehicle, the driver feels control regardless of the actual use. This suggests that the psychological stability from the fact that (s)he has smart car technology is more important to the driver than being assisted by the actual use of smart car technology. In Model 5, the influence of the frequency of smart car technology use turned insignificant, with the coefficient changed to negative. As a reason, it is presumed that if the control of the vehicle is high, it is not necessary to utilize smart car technology. More careful interpretation of the causal relationship is needed to inspect if the use of smart car technology enhances the sense of control, or if the lack of control over the vehicle leads to its use.

Table 5. Results of hierarchical regression analysis for control

		Perceived control (<i>beta</i>)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Personal factors	Gender (male=1)	0.302***	0.214***	0.212***	0.205***	0.214***	0.185***
	Age (21~59)	0.083	-0.169*	-0.067	-0.067	-0.001	-0.003
	Region (Seoul=1)	0.081	0.070	0.095	0.078	0.060	0.048
	Education (Undergraduate or higher=1)	-0.024	-0.084	-0.075	-0.091	-0.103*	-0.116*
	Income	0.055	0.049	0.027	-0.019	-0.052	-0.041
	Driving experience (month)		0.337***	0.217**	0.183*	0.141	0.155*
Vehicle factors	Ownership (personal ownership=1)			-0.123	-0.116	-0.123*	-0.089
	Co-using status (solely drive=1)			0.142*	0.137*	0.130*	0.104
	Period of car use			-0.087	-0.067	0.014	-0.011
	Frequency of driving per week (1~10)			0.264***	0.267***	0.252***	0.247***
	Amount of driving time per day (minute)			0.133**	0.115*	0.068	0.084
	Domestic / foreign car (domestic=1)				-0.024	-0.032	-0.017
	New / Used car (new=1)				0.117	0.124	0.123
	Car price				0.082*	0.040*	0.042*
Smart car technology factors	Number of possession					0.204***	0.166**
	Utilization rate					-0.020	-0.009
	Frequency of use					0.191***	-0.006
	Ease of use						0.149
	Satisfaction						0.179*
R Square		0.112	0.155	0.281	0.308	0.372	0.427
Adjusted R Square		0.099	0.140	0.256	0.277	0.338	0.392
F		8.282***	16.550***	11.227***	4.076**	10.750***	14.938***

*p<.05, **p<.01, ***p<.001

4.2.2. Attachment

In the case of attachment, the number of variables whose influence was verified is small, compared to the control. None was found to be significant in Model 1. In Model 2, age ($\beta = -0.226$, $p < .05$) and driving experience ($\beta = 0.226$, $p < .05$) were verified to have influence on attachment. However, the influence of the two variables was not proved to be significant in the models after the vehicle factors and the smart car technology factors were added.

In model 3 with the vehicle factors, the effects of the period of vehicle use ($\beta = -0.137$, $p < .05$) and the frequency of driving ($\beta = 0.289$, $p < .001$) were confirmed. In Model 4, it was found that drivers feel more affection for car when driving is frequent ($\beta = 0.289$, $p < .001$) and the vehicle is a foreign one ($\beta = -0.132$, $p < .05$).

In the model 5 and 6 that put the smart car technology factors, the frequency of driving per week ($\beta = 0.284$, $p < .001$ in Model 6), foreign vehicle ($\beta = -0.126$, $p < .05$ in Model 6), the number of smart car technology possession ($\beta = 0.182$, $p < .01$ in model 6) and utilization rate of smart car technology ($\beta = 0.116$, $p < .05$ in model 6) were verified.

Among the results, the most notable variables are the frequency of driving per week, if the car is domestic, the number and smart car technology use and the utilization rate of smart car technology. In terms of vehicle factors, the influence of the driving frequency is greater than the average driving time per day as in the case of control. Also, considering the regression coefficient and the significance of the number of possession are higher than the utilization rate, it is interpreted that the possession of smart car technology has more considerable influence not only on the control but also on the attachment, regardless of the actual use. This influence has nothing to do with whether drivers feel smart car technology easy or satisfactory. In other words, if drivers have smart car technology in their vehicles, the attachment to the vehicle can be increased. Attachment is not related to the price of the vehicle, but the drivers feel a bigger attachment when they have a foreign car than a domestic car.

Table 6. Results of hierarchical regression analysis for attachment

		Attachment (<i>beta</i>)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Personal factors	Gender (male=1)	0.042	-0.017	-0.007	0.000	0.005	0.004
	Age (21~59)	-0.058	-0.226*	-0.144	-0.138	-0.115	-0.123
	Region (Seoul=1)	0.099	0.091	0.108	0.093	0.080	0.079
	Education (Undergraduate or higher=1)	0.006	-0.034	-0.021	-0.028	-0.038	-0.031
	Income	0.021	0.017	-0.011	-0.049	-0.075	-0.071
	Driving experience (month)		0.226*	0.143	0.105	0.094	0.097
Vehicle factors	Ownership (personal ownership=1)			-0.040	-0.018	-0.026	-0.006
	Co-using status (solely drive=1)			-0.020	-0.038	-0.048	-0.061
	Period of car use			-0.137*	-0.101	-0.021	-0.019
	Frequency of driving per week (1~10)			0.285***	0.289***	0.282***	0.284***
	Amount of driving time per day (minute)			0.087	0.074	0.043	0.044
	Domestic / foreign car (domestic=1)				-0.132*	-0.134*	-0.126*
	New / Used car (new=1)				0.055	0.062	0.063
	Car price				0.066	0.021	0.022
Smart car technology factors	Number of possession					0.195**	0.182**
	Utilization rate					0.119*	0.116*
	Frequency of use					0.061	0.011
	Ease of use						-0.053
	Satisfaction						0.159
R Square		0.016	0.035	0.140	0.171	0.222	0.233
Adjusted R Square		0.001	0.017	0.111	0.135	0.180	0.187
F		1.051	6.490*	7.864***	3.951**	6.816***	2.337

*p<.05, **p<.01, ***p<.001

5. Discussion and Conclusion

This article has explored how the adoption of smart car technologies affect the driver's perception of the vehicle's functions and space through perceived control and attachment. The results of the survey of 340 drivers uncovered that safety or convenience technologies such as black box, front / rear and side monitoring technology had been popularized, while the degree of use, ease of use, and satisfaction were low in case of sensibility technology such as speech recognition. Drivers had an average of 4.33 smart car technologies, and they had used most of the technologies more than once. In general, drivers evaluated positive about smart car technology in terms of ease of use and satisfaction. However, the number of possession and utilization of smart car technology differ among sociocultural groups, so it is necessary to grasp the status in more detail by groups. For example, by examining whether the types of smart car technologies people have in their cars are different, strategies for smart car technology development, application, and sales could be developed.

Interestingly, the influence of smart car technology possession was found to be powerful, regardless of the actual use. This indicates that the driver can feel psychological stability and ties with the car when there are in-vehicle smart technologies even though they are not used. We can consider this result in developing a marketing strategy. Since the effect of smart car technology is greater in the context of the psychological effect of the 'owner' rather than the actual experience of the 'user', selling smart car technologies in a bundle or as basic built-in functions can be more effective in enhancing driver satisfaction. At this time, however, it is required to consider driver's habits and characteristics such as driving experience and frequency of use.

This study has limitations in that only drivers were surveyed. Car users include not only drivers but also passengers. They need a sophisticated access as they are likely to use infotainment technology more often than drivers. It is also suggested to investigate how people who do not currently own or drive cars are aware of smart car technology, as they are potential future customers of smart cars.

Despite the limitations, this paper has a value in conducting the research in the context of daily life, in contrast to previous studies which mainly focused on the effects of specific technologies on driver behavior in an experimental situation. In addition, by accessing possession and use separately, the interesting result that the ownership of the smart car technology is more important than the utilization could be obtained. It is also an advantage of this study that the influence of smart car technology is examined in relation to individual factors and vehicle related factors.

Based on the conclusions drawn from this article, structural equation model can be applied to verify the relationship among variables more clearly as a future research. In addition, it is possible to scrutinize whether the drivers are typed according to the repertoire of the smart car technology. It is also possible to grasp concrete use of smart car technology before, during, and after driving in order to examine the effects in detail. In the sense that socio-cultural differences can determine driving behaviors, it may be possible to carry out comparative group studies or international comparative studies. Through further approaches, we will be able to understand how the identity of a car is changing, and how this change affects our everyday life, in the era of smart cars.

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