Drivers' Activities in Cars during Serious Traffic Congestion

Toward the Development of ICTs for Enjoying Traffic Congestion

Kiichiro Hatoyama
Top Runner Incubation Center for Academia-Industry Fusion, Nagaoka University of Technology
Nagaoka, Niigata, Japan
email: kii@vos.nagaokaut.ac.jp

Masaya Nishioka
Department of Civil and Environmental Engineering
Nagaoka University of Technology
Nagaoka, Niigata, Japan
email: s153343@stn.nagaokaut.ac.jp

***Abstract*— One possible way of reducing drivers' psychological burden under severe traffic congestion is to reframe their travel time as "valuable time" via "Information and Communication Technologies (ICTs) for enjoying traffic congestion." Such technology, of course, must be safe for drivers and satisfy legal restrictions. As a first step, a questionnaire survey was conducted to grasp drivers' activities during traffic congestion, thus clarifying the possible content of these ICTs, as well as the target groups. Overall, the majority of participants reported engaging in conversations to pass the time when they had passengers in the car. Furthermore, for long-term congestions, these drivers selected more active activities (i.e., activities requiring specific motions to be performed). Drivers without any passengers tended to select passive activities (i.e., activities that do not require specific motions) during short-term traffic congestions. Younger drivers and more creative and curious drivers also selected active activities during long-term congestions. Taken together, the results suggest that one of our future main targets for these ICTs is young people with passengers (particularly for long-term traffic congestions).**

Keywords–driver's activities; mobile application; ICT; traffic congestion; novel concept.

I. INTRODUCTION

In this study, we introduce a new idea for coping with traffic congestion. In the following sections, we relate past work in this area and then provide an outline of the present study.

A. A new idea for coping with traffic congestion

In many countries, traffic congestion is a serious problem that lacks an effective solution. In large cities, the main reason for traffic congestion is usually rapid motorization in conjunction with slow road infrastructure construction. However, severe congestions also commonly occur in relatively small cities, especially after events or festivals that generate a large, unusual traffic demand. Resolving these problems requires large-scale infrastructure construction, which takes a long time to realize. Therefore, non-structural countermeasures, such as information provision, signal control, public transportation promotion, etc., have been conducted for some time to reduce or disperse traffic demand, as is shown in the case of Los Angeles [1]. Nevertheless, it remains difficult to solve the problem of traffic congestion using these methods.

Travel time has long been considered a negative aspect of travelling. Especially for drivers, travel time during traffic congestion is regarded as a psychological burden because of the behavioral and attentional restrictions imposed by driving. Hennessy et al. revealed a positive relationship between traffic congestion and aggressive driving [2], as did Shinar et al. [3]. To deal with the long waiting times that accompany traffic congestion, people are increasingly adopting various Information and Communication Technologies (ICTs). ICT, along with mobile telecommunication technologies and autonomous driving, is advancing rapidly nowadays, and such technologies can potentially reframe travel time as "valuable time." This, in turn, might lead to some form of psychological resolution for serious traffic congestion. In the present study, these technologies are termed "ICTs for enjoying traffic congestion." Considering that car manufacturers, electronics companies, and researchers are now competing to develop travel-related technologies, such as "head-up displays" [HUDs], which allow for projecting information on the front windows of vehicles [4][5], it is necessary to accumulate knowledge on the content of these ICT applications that is desirable for drivers to make use of their time during traffic congestion. In this study, in order to aid in the future development of "ICTs for enjoying traffic congestion," a questionnaire survey was conducted on drivers' activities during traffic congestions. A specific focus was on the target groups and contents of these ICTs.

B. Related work

In the literature on ICT applications for drivers, Siuhi and Mwakalonge reviewed the latest trends and found that route planning, traffic safety, parking information, transportation data collection, and fuel emissions and consumption are the main categories of ICTs for drivers [6]. Among them, route planning information via smartphones appeared to be most acceptable for young drivers [7], and many drivers found stop sign information provision as a traffic safety measure useful [8]. Ilarri et al. introduced the present course of development of applications for vehicular ad hoc networks (VANETs) using extensive references [9]. However, there are no studies, to our knowledge, on developing ICTs to reduce drivers' psychological burden during congestion.

Psychology researchers have identified several factors that can shorten human time perception. Particularly, Maister noted that "the more valuable the service, the longer the customer will wait" [10]. In exploring what qualities make a service "valuable," Failing, et al. revealed that services with

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"higher reward" might induce attentional deployment and shorten people's subjective time [11]. Furthermore, Edwards, et al. found that "high intensity exercise" in sports can shorten subjective time [12]. Misuraca et al. examined groups of maximizers and satisficers, and found that maximizers (who generally choose the option with the highest expected utility) tend to perceive time as shorter during the "decision-making" process than do satisficers (who generally choose the "good-enough" alternative) [13]. From the viewpoint of enjoyment, Sackett, et al. found that time passes more quickly during enjoyable experiences [14], and Xu, et al. mentioned that switching between more and less entertaining tasks can generate overestimation of time duration [15]. So far, there is little research focusing on drivers' time perception.

Therefore, our proposed concept of "ICTs for enjoying traffic congestion" can be considered new and requiring further study as a potential intervention for the psychological burden experienced by drivers in serious traffic congestions.

C. Outline of this work

The outline of this work is as follows. Section II provides an overview of the questionnaire survey. Section III introduces the statistical results of the survey, including several activity choice models. Finally, the conclusions and suggestions for future work are mentioned in Section IV.

II. SURVEY OVERVIEW

In this section, an overview of the web questionnaire survey is described.

A. Sample selection

In this paper, a web-based questionnaire survey was conducted to understand drivers' activities to pass the time during serious traffic congestion. To investigate the variety of actual behaviors, this method is considered to be more realistic and cost-effective for collecting data about drivers' experience than in-situ observations conducted by equipping drive recorders to sample vehicles. Considering the research objective, respondents with driving experience in traffic congestion were desired. Therefore, the survey was conducted via a web-based research company. Their monitors were screened using three criteria: have a drivers' license, have more than one year of driving experience, and have experienced being caught in a severe traffic jam. The respondent pool was also limited to those aged 20–59 years, in consideration of the age-related declines in driving skills. The percentage of respondents in each age group (20–29, 30–39, 40–49, and 50–59) was set to be 25% by the survey company. The size of total valid samples was 311. An outline of the questionnaire and inclusion criteria are provided in Table I. Since the sample size appears to potentially have insufficient power, we decided that the current number of participants could serve as a preliminary trial to gain a rough understanding of drivers' activities.

B. Questionnaire item details

As shown in Table I, the questionnaire asked respondents about their activities in the car during the most serious instance of traffic congestion ever experienced, along with their personality and driving tendencies. When a serious traffic jam is expected, a driver must leave after considering how to spend that time. Therefore, we determined that even this method can collect drivers' needs and opinions. Details of these items are introduced in the following three subsections.

TABLE I. OVERVIEW OF THE WEB QUESTIONNAIRE SURVEY

Date	January 5–6, 2018
Inclusion criteria	1) Driver's license holder 2) Individuals with driving experience 3) Individuals with experience of being caught in traffic congestion
Effective samples	Total valid sample: 311 (male = 147, female = 164) Percentage of each age group: 25% (20–29), 25% (30–39), 25% (40–49), and 25% (50–59)
Contents of the questionnaire	
(1) Congestion situation concerning the most serious traffic jam ever experienced: time duration, speed, with/without passengers, etc.	
(2) Activities in the car during the traffic jam (multiple answers were allowed)	
(3) Personality traits and tendencies while driving	

1) Activities in the car

Respondents' activities in the car during the traffic congestion were categorized as active activities and passive activities. Active activities refer to activities requiring specific motions to perform, while passive activities are activities that do not require such motions. In the survey, specific activities were set for each category to standardize the responses, as follows. Respondents were simply asked to indicate if they had experienced each activity or not during the most serious traffic congestion that they had experienced.

- Active activities: making conversation, eating snacks, singing, playing mobile games, surfing the web, telling funny/horror stories, and answering riddles/quizzes
- Passive activities: listening to music, watching TV, and listening to the radio

2) Personality

Items were prepared to assess drivers' personalities by referring to the egogram proposed by J. M. Dusay in the field of transactional analysis in personality psychology [16]. Egogram is an easy and compact method of creating questionnaire items while considering the burden on respondents. The egogram involves dividing individuals' personalities into five factors (controlling parent [CP], nurturing parent [NP], adult ego state [A], free child [FC], and adapted child [AC]). The meaning of each factor and their specific items are shown in Table II. Three items were selected from among ten original items for each factor in accordance with the survey context. Each item is rated on a 6-point Likert scale: 1 = disagree, 2 = moderately disagree, 3 = slightly disagree, 4 = slightly agree, 5 = moderately agree, 6 = agree).

TABLE II. ITEMS FOR EACH OF THE FIVE PERSONALITY FACTORS

Factor	Meaning	Measuring questions
CP: Controlling parent	Sense of justice, moral, responsibility, etc.	- I stick to my own way rather than go along with others. - I'm strict on promises, rules, and times. - I clearly say whether I am for or against
NP: Nurturing parent	Tenderness, kindness, acceptability, etc.	- I am not able to refuse somebody's request. - I'm an obliging person. - I often pamper others unintentionally.
A: Adult ego state	Intelligence, logicality, etc.	- I usually don't waste money and time. - I do not get disturbed emotionally. - I firmly make plans in everything.
FC: Free child	Activeness, creativity, curiosity, etc.	- My mind is always filled with ideas and plans that have not been fully considered. - If I think of anything, I act fast. - I like to liven up the atmosphere by joking.
AC: Adapted child	Cooperativity, tolerance, politeness, etc.	- I act cautiously in everything - I usually care about the words and attitudes of others. - I often cannot express what I think.

3) Driving tendencies

Items to assess driving tendencies in general and during traffic congestion were created with reference to Fujimoto's driving scale [17], supplemented with items related to their tendencies during traffic congestion, such as cellphone operation. All items are shown below. Each item is rated on a 6-point Likert scale (the same one as for personality).

[In general]

- *Confidence in driving*: I'm confident in driving and can concentrate on driving.
- *Fond of driving*: I'm fond of driving.
- *Use of detours*: I actively use detours.
- *Attentive driving*: I rarely drive inattentively.
- *Manner compliance*: I usually keep traffic manners and rules more than others.
- *Driving without a break*: I often drive without taking a break.

[During traffic congestions]

- *Use of cellphone*: When I get caught in traffic jams, I unintentionally pass the time by watching my cellphone.
- *Quick to irritate*: I get irritated immediately even in a light traffic jam.

C. Survey hypotheses

The following two hypotheses were devised.

a) Drivers' personality factors and driving tendencies affect how they pass the time during traffic congestion.
b) The existence of passengers and the seriousness of the traffic congestion influence drivers' choice of active activities.

III. RESULTS

The following sections outline the results of the statistical analyses.

A. Situations of traffic congestions

Figure 1 shows the distribution of trip purposes and whether there were passengers in the car or not when the respondents encountered the serious traffic congestion. The percentage of trips with passengers along with each trip's purpose are also shown in the figure. The most frequent purpose was "sightseeing/trip," and most respondents who provided this answer noted that there were passengers in the car with them. On the other hand, in the case of "business" and "commuting," respondents were less likely to have passengers compared with the other purposes. It was thought that for these purposes, respondents might have been more irritable and sensitive to delay than for other purposes because of their arguably greater schedule constraints and ill-preparedness for serious traffic congestion; respondents' choice tendencies might also differ for these purposes than for the others. Therefore, for all further analyses, these two purposes were excluded from the samples.

Figure 2 shows the distribution of the congestion durations

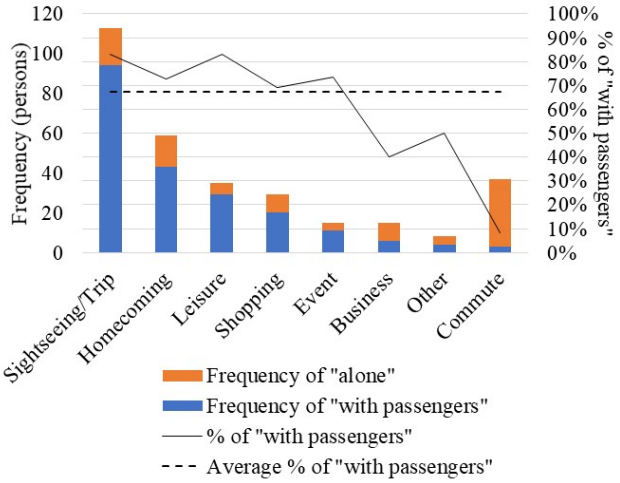

Figure 1. Trip purposes and the existence of passengers in serious traffic congestion ($N = 311$)

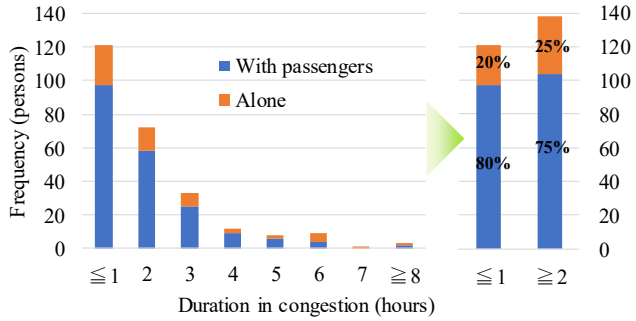

Figure 2. Distribution of congestion duration and its relation to existence of passengers ($N = 259$)

according to whether there were passengers in the car. Notably, the majority of respondents reported their most serious congestion as lasting for one hour or less. If congestion duration was divided into two groups—one hour or less and two hours or more—the frequencies were roughly equal. The proportion of respondents with passengers was also similar between these two groups ($t = 0.925$, $p = 0.356$). Thus, for subsequent analyses, the sample was divided into two categories: "one hour or less" and "two hours or more."

Participants also were asked to report the perceived speed of the traffic congestion using two categories: "slowly move" (assumed to be congestions caused by traffic concentration in expressways) and "hardly move" (assumed to be congestion caused by accidents or other cases). The distribution of congestion duration, existence of passengers, and speed is shown in Figure 3.

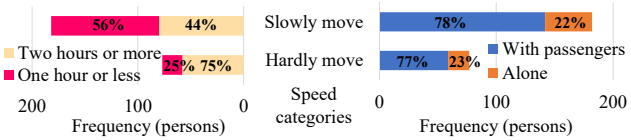

Figure 3. Congestion duration, existence of passengers, and speed categories ($N = 259$)

The ratios of the existence of passengers were the same in both speed categories ($t = 0.247$, $p = 0.805$), significantly higher for the "hardly move" category ($t = 4.62$, $p \leq 0.01$).

B. Distribution of driving tendencies

Figure 4 shows the results of respondents' driving tendency. In general, they appeared to have a high level of manner compliance and like to drive without a break. For driving tendencies during congestion, 32% of respondents reported using mobile phones and 48% reported becoming irritated. As these percentages were higher than was the percentage of individuals with low manner compliance (22%), it seems that manner compliance is not directly linked to actual behaviors in traffic congestion. This result suggests that it is more important to ensure their safe and effective use of time and the reduction of their psychological burden via ICTs than to improve their manners.

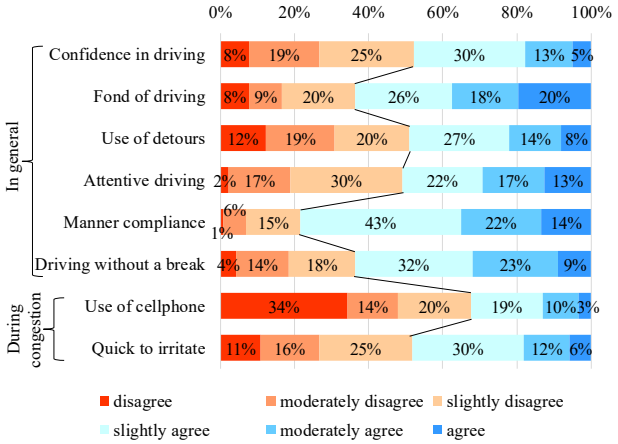

Figure 4. Distribution of responses for driving tendencies ($N = 259$)

C. Activity choices during traffic congestion

For this analysis, "conversation" was separated from the other active activities because a high proportion of respondents selected it when there were passengers in the car. Therefore, activities were re-categorized as conversation, active activities, and passive activities.

Figure 5 shows how respondents passed their time in the cars during serious traffic congestions according to whether there were passengers in the car or not. When there were passengers, almost 80% of respondents selected conversation. However, if the drivers were alone ($n = 58$), approximately 20% did nothing. Moreover, 40% of respondents with passengers selected active activities, whereas less than 20% selected such activities if they were alone. Although the percentages of those who chose passive activities were high, regardless of the existence of passengers, a high proportion of respondents chose passive activities, especially if they were alone. Based on these findings, it is possible to assume that conversation and active activities were preferable to drivers when they were with passengers, while some drivers appeared to not pursue any activity when they were alone.

D. Personality factors affecting active and passive activities

Table III shows the average score for each personality factor when dividing respondents according to their choice of activities. The scores of each personality factor were normalized to range from 0 to 1, with 0 denoting a low score and 1 denoting a high score. The FC factor appeared to be a dividing factor for active and passive activities: that is, those who chose active activities had higher FC scores. When focusing on passive vs. non-passive activities, the CP and A scores significantly differed.

E. Activity choice model

Logistic regression analyses were conducted to explain what factors were related to respondents' choice of active and passive activities.

1) Choice model for active activities

The above analyses revealed that the existence of passengers and the FC personality factor were influential in

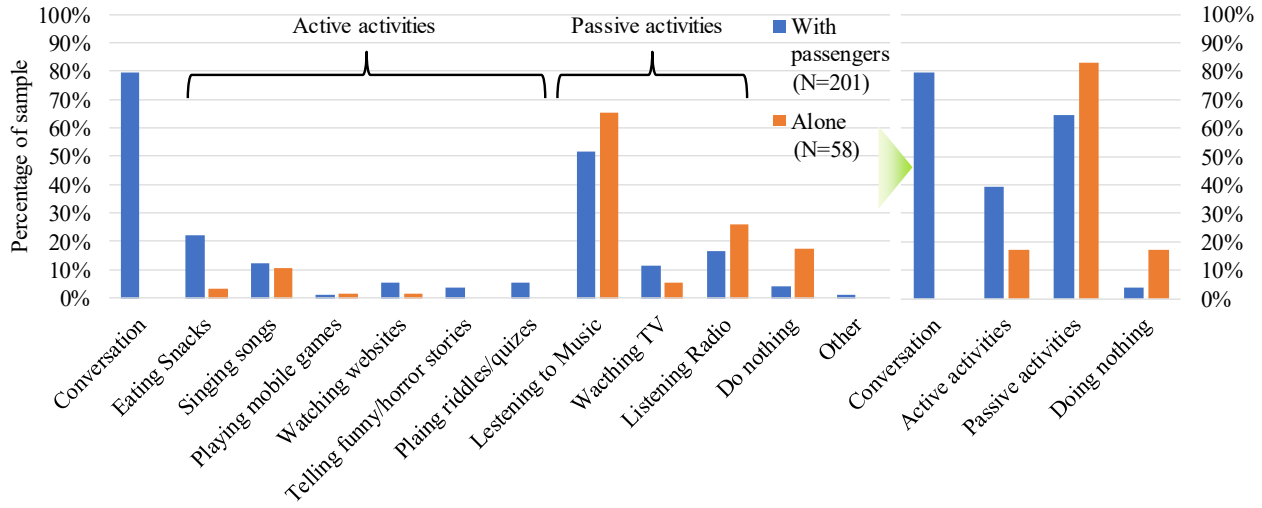

Figure 5. How to spend in cars in serious congestions

TABLE III. COMPARISON OF AVERAGE VALUES OF PERSONALITY FACTORS ACCORDING TO ACTIVITY CHOICE

Personality factor	Active and passive *df* = 265			Active and non-active *df* = 257			Passive and non-passive *df* = 257		
	Active (*N* = 89)	Passive (*N* = 178)		Active (*N* = 89)	Non-Active (*N* = 170)		Passive (*N* = 178)	Non-Passive (*N* = 81)	
CP	0.57	0.57		0.57	0.54		0.57	0.51	**
NP	0.54	0.52		0.54	0.51		0.52	0.51	
A	0.53	0.54		0.53	0.52		0.54	0.49	**
FC	0.54	0.50	*	0.54	0.46	***	0.50	0.47	
AC	0.59	0.58		0.59	0.59		0.58	0.60	

*: P<0.10, **: P<0.05, ***: P<0.01

the selection of active activities. Therefore, a logistic regression analysis was conducted (see Table IV) to clarify how personality factors, the existence of passengers, the congestion situation, and driving tendencies influenced the selection of active activities.

The coefficients were estimated using a significance probability of 90% and the stepwise method, and the analyses were carried out separately by congestion duration ("one hour or less" and "two hours or more"). The findings from the analysis were as follows.

a) Factors related to active activities during short-term congestions

In short-term (one hour or less) traffic jams, active activities were significantly more likely to be chosen by drivers who used their mobile phones during congestion and who have high manner compliance (see Table IV). Furthermore, despite the above findings, the existence of passengers and FC scores did not have a significant association with active activities.

b) Factors related to active activities during long-term congestions

Unlike the results for the short-term congestions, the existence of passengers and FC scores did significantly relate to selection of active activities during long-term congestions (two hours or more). In addition, when the traffic jam was

TABLE IV. ACTIVE ACTIVITY CHOICE MODEL ACCORDING TO CONGESTION DURATION

Variable		1 hour or less	2 hours or more
Frequency	Active actions	40	49
	Non-Active	81	89
Output of binary logit model		Coefficients	Coefficients
	Intercept	-3.72***	-1.87
Situation of congestion	Hardy move		1.27***
	With other passengers		1.93***
Personal Attribute	Age		-0.07***
Personality factors	FC		3.56***
Driving tendencies	Manner compliance	0.43**	
	Use of cellphone	0.44***	
Accuracy of the model	Likelihood ratio χ^2	11.18***	38.69***
	Hit ratio	65.3	80.3

*: P<0.10, **: P<0.05, ***: P<0.01

"hardly moving" and respondents were young, respondents had a stronger tendency to select active activities.

c) Comparison of active activity models between short- and long-term congestions

Comparing the choice models for short- and long-term congestions revealed that active activities were significantly more influenced by drivers' driving tendencies in short-term congestions, while in long-term congestions, they were significantly more influenced by drivers' personality factors, age, and congestion situations. These results suggest that

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when developing new ICTs for drivers, it is necessary to understand that the factors that must be considered might change according to the duration of the traffic congestions.

2) Choice model for passive activities

In contrast to active activities, passive activities were adopted more frequently when drivers were alone. As shown in Table III, CP and A scores were significantly related to choice of passive activities. Therefore, a logistic regression analysis was conducted again in the same way as in the previous section. The results are shown in Table V.

a) Factors related to passive activities in short-term congestions

As shown in Table V, it is clear that respondents tended to select passive activities when driving alone in short-term congestions. Notably, none of the personality factors were significant (like the results for active activities). Furthermore, drivers who reported that they liked to drive and could tolerate traffic jams tended to select passive activities.

TABLE V. PASSIVE ACTIVITY CHOICE MODEL ACCORDING TO CONGESTION TIME

Variable		1 hour or less	2 hours or more
Frequency	Passive action	76	102
	Non-passive	45	36
Output of binary logit model		Coefficients	Coefficients
	Intercept	1.81*	1.91*
Situation of congestion	With other passengers	-2.22***	
Personal Attribute	Age		-0.05**
Personality factors	CP		2.23*
Driving tendencies	Fond of driving	0.51***	
	Use of detours		0.33**
	Quick to irritate	-0.36**	
Accuracy of the model	Likelihood ratio χ^2	27.05***	12.17***
	Hit ratio	75.9	70.7

*: P<0.10, **: P<0.05, ***: P<0.01

b) Factors related to passive activities in long-term congestions

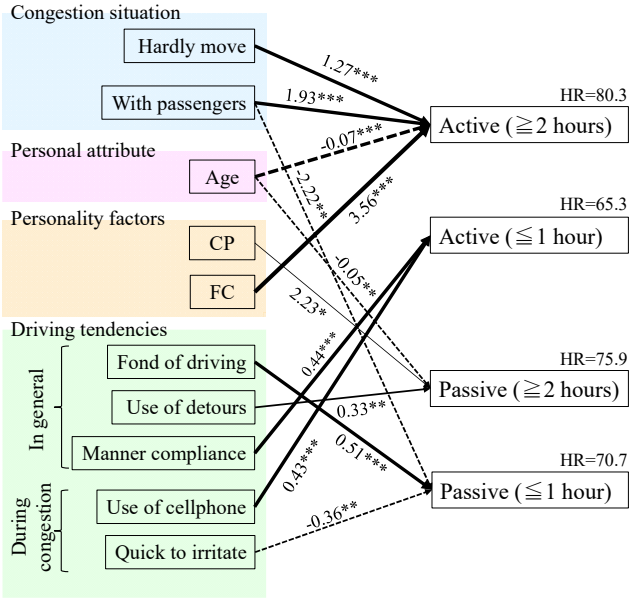
In long-term congestions, the existence of passengers was not significantly related to passive activity choice. Among the personality factors, only CP scores was significantly related. Finally, drivers that tended to use detours often preferred passive activities.

c) Comparison of passive activity models between short- and long-term congestions

The previous analysis suggested that both CP and A scores influenced passive activity choice. However, the regression analysis showed that only CP score was related to passive activity choice, and only in long-term congestions. One possible reason for this is multicollinearity. The correlation coefficient between CP and A was 0.273, which is considered a weak correlation in psychology research. Multicollinearity was tested for in other respects, and it revealed no other problems. Furthermore, as in the case of active activities, personality factors related to the choice of passive activities only in long-term congestions. When drivers were alone in short-term traffic congestion, they appeared more likely to choose passive activities.

3) Comparison of the two activity choice models

Figure 6 provides a summary of the activity choice models with path coefficients for the factors significantly related to active and passive activities. The solid lines denote positive effects and the dotted lines denote negative effects. In addition, the thickness of the lines expresses the significance level of the path coefficient.



*: p<0.10, **: p<0.05, ***: p<0.01

Figure 6. The summary of the activity choice models

The results showed that drivers' personal attributes and personality factors had significant associations with activity choice only during long-term traffic congestions, whereas driving tendencies had significant relations only for the short-time traffic congestions. It therefore seems natural that drivers that tend to use mobile phones during traffic congestions might choose active activities in short-term congestions. However, a surprising finding was that during short-term traffic congestions, higher manner compliance was associated with selection of active activities, which included some activities deemed illegal while driving (e.g., surfing the web, playing mobile games). It is possible that individuals with higher manner compliance do try to find legal active activities to pass the time during traffic congestions.

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IV. CONCLUSION AND FUTURE WORK

This web-based questionnaire survey of drivers was designed to identify activities used to pass the time during serious traffic congestions, and clarify the factors that related to the choice of active and passive activities. Conversations were found to be effective for passing the time for most drivers with passengers. The activity choice models also revealed that drivers without passengers tended to choose passive activities in short-term traffic congestions, while drivers with passengers tended to choose active activities during long-term congestions. Therefore, it seemed important to promote active activities, including conversation, when there are passengers in the car. In addition, when focusing on long-term congestions, younger drivers and drivers with higher FC scores tended to select active activities.

Based on these results, one of promising future targets for ICTs aimed at helping drivers pass the time during long-term traffic congestion are "young people with passengers." The use of ICTs might be particularly helpful for traffic congestions that are "hardly moving." Once a target is determined, it becomes clear what type of content should be developed to promote the drivers' actions in the cars. It can be an expected technology, for example, to offer conversation automatically based upon the passengers' attributes and preferences.

On the other hand, when focusing on short-term traffic congestions, drivers' driving tendencies had a stronger influence on their activity choice compared personality factors. In addition, some passengers who were alone did not choose any activity. Because even drivers with high manner compliance tend to engage in active activities, such as using cellphones, which is considered an unsafe behavior, during short-term congestions, it might also be necessary to develop ICTs that can help drivers effectively pass their time safely. A handsfree quiz function with voice recognition can be one of the solutions.

The future tasks in this area are the development of apps for drivers that conform to legal restrictions, and checking to what extent these apps gratify drivers under severe traffic congestions. In general, drivers cannot use most existing apps and games since watching screens is a traffic violation. Therefore, future apps for drivers should be primarily operated by drivers' voice. It is important, of course, that such apps keep drivers' attention on their driving, without immersing them too deeply in the app. In Japan, it is said that drivers are so disciplined that comparatively immersive apps of "ICTs for enjoying traffic congestion" might be applicable. However, when providing such apps to drivers, it is critical to understand the cultural backgrounds of cities where they are introduced.

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