INFLUENCE OF ADVANCED TRAVEL TIME INFORMATION ON DRIVERS ROUTE CHOICE BEHAVIOR AT EXPRESSWAYS

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ABSTRACT

Travel time information affects drivers' route choice behaviour, and is therefore regarded as one of the effective measures to ease traffic congestion. We conducted the questionnaire survey about travel time information at Service Areas (SA) and Parking Areas (PA) on the expressways around Nagoya City in Japan. The questionnaire mainly consisted of questions about the consciousness and the needs of drivers for travel time information and their route choice behaviour. It reveals that approximately 80% of drivers accept ±10 minutes error of travel time information. When an increase or a decrease arrow was added to travel time information, it had a considerable influence on their route choice behaviour. As a result, it was clarified that the display of the arrow on travel time information had possibility to relieve traffic congestion effectively.

Keywords: Travel Time, Allowable Error, Route Choice, Expressway

INTRODUCTION

Recently, various types of traffic information have obtained by the development of observation equipments of traffic conditions and the innovation of ITS (Intelligent Transport Systems) technologies. Consequently, it becomes easy to provide traffic information on present or past traffic conditions. In particular, valuable travel time information services such as increase or decrease information of travel times or predicted travel times are strongly expected to be provided on an expressway. Travel times, past or present travel times, are

able to be estimated accurately from traffic counts (Matsumoto *et al.* 2006). Although the accuracy of estimated travel times, especially during traffic congestion periods, is still low due to dynamic traffic phenomenon, the provision of the accurate current/past travel time information can improve the service of an expressway and also induce drivers to change their routes. The travel time information is regarded as one of the effective measures to ease traffic congestion without enforcement of their route changes. However, before these travel time information services are implemented at the expressway, it is required to catch drivers' consciousness and needs for the travel time information.

Furthermore, the methods to provide additional information to the travel times have been developed (Oguchi *et al.* 2003, Uno and Iida 2002, Ahn *et al.* 2006). It becomes possible to provide advanced travel time information. In fact, the Tokyo Metropolitan Expressway starts the unique service to provide an increase information of travel times on the traffic information board from February 2006 and now a decrease information is also provided.

In this study, in order to grasp drivers' consciousness and needs for the travel time information, we conducted a questionnaire survey about travel time information to drivers resting at Service Areas (SA) and Parking Areas (PA) on expressways around Nagoya City in Japan. The PA mainly has a rest space, lavatories, a cafeteria and a shop. The SA has the same facilities of the PA and also a restaurant and a gas station. Generally, the SA is bigger than the PA.

Using the results of the survey, the influence of the advanced travel time information on drivers' route choice behaviour is analyzed with a hypothetical network.

OVERVIEW OF SURVEY AND ITS RESULT

Survey Overview

The questionnaire survey was conducted by interview style in November 2006 at five spots of SA/PA on the expressways around Nagoya City (Tokai-Hokuriku Expressway Seki SA, Toukai-Kanjo Expressway Minokamo SA, Chuo Expressway Enakyo SA, Tomei Expressway Kamigo SA and Miai PA) in Aichi and Gifu prefectures, Japan as shown in Figure 1.

The questionnaire consisted of attributes of an interviewee, available sources to obtain travel time information during driving on expressways, their consciousness about the existing travel time information, their needs for travel time information, and so forth. The number of interviewees was 672 for two survey days.

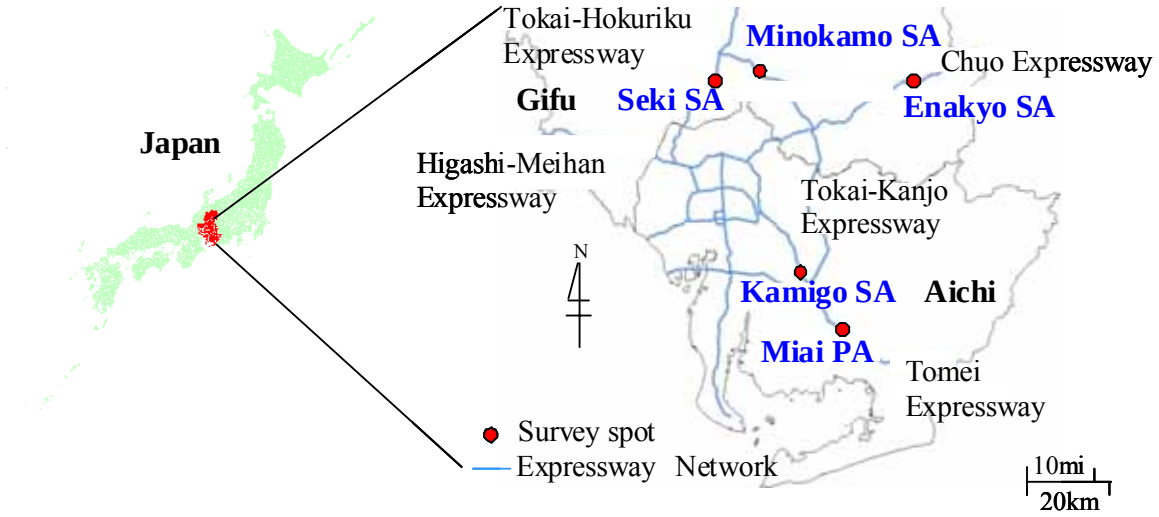


Figure 1 – Survey spots and expressway network

Table 1 shows the attributes of the interviewees and travels. A purpose of the travel accounts for about 70% of leisure purpose and 10% of business purpose. A frequency of using an expressway has a high proportion of "1 or 2 times a month" and "a few times a year". In terms of the age, the interviewees are mainly 30's, 40's or 50's. The survey was conducted on weekend. Therefore, the survey results are recognized as drivers' consciousness during leisure travel at weekend on an expressway.

Table I – Attributes of interviewees and their travels

	Attribute
Purpose of travel	Leisure: 73%
	Business: 10%
Frequency of using expressway	1 or 2 times a week: 16%
	1 or 2 times a month: 37%
	A few times a year: 25.5%
Age	30 ' s: 24%, 40 ' s: 18%, 50 ' s: 25%
Vehicle type	Passenger car: 93%
Gender	Male: 88%

Route Choice and Source of Traffic Information

Figure 2 shows reasons why drivers choose this route to the survey spot. The answer "the shortest-distance" and "the shortest-travel-time" account for almost all proportion of the reason of their route choices when the answer "Only this route" is omitted from the calculations. The ratio of answer "the shortest route" for the reason is about three fourth of the total. In Japan, expressways are toll road. If the pair of entry and exit is identical, the same toll is charged even for different routes. Namely, the toll is determined only by the pair of the entry and exit ramps regardless of the route.

In the situation of steady and uncongested traffic condition, the shortest-distance route means the shortest travel time route. Therefore, it is found that travel times have the largest effects on their route choices.

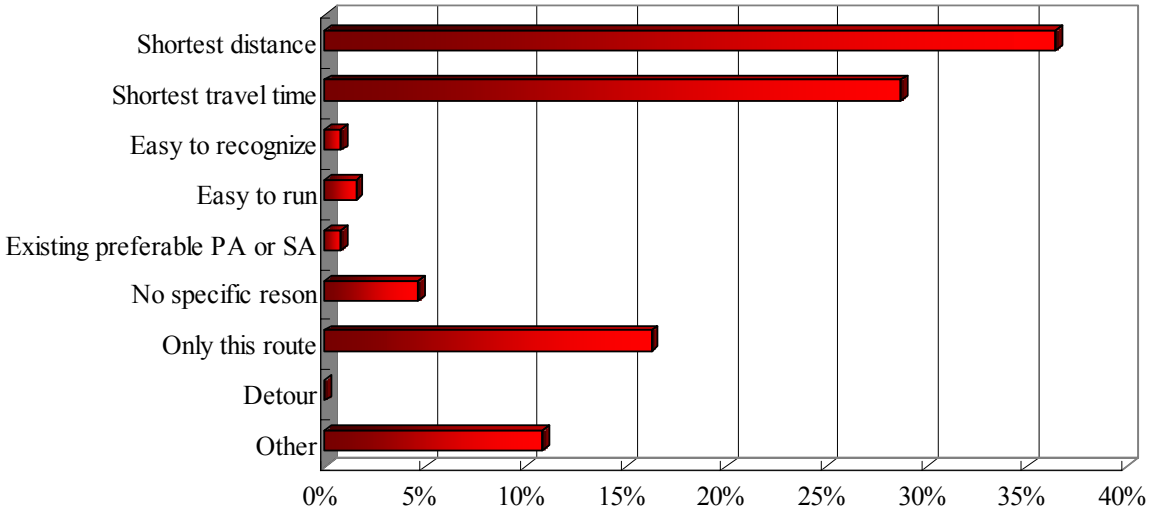


Figure 2 – Reason for choosing the route

Travel Time Information obtained

The result of the question, “How do you obtain the travel time to your exit ramp during driving?”, is shown in Figure 3.

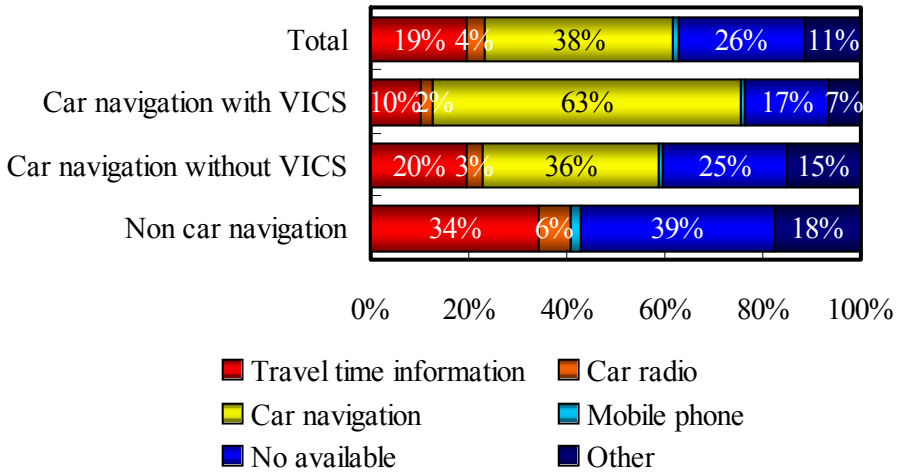


Figure 3 – Source for obtaining the travel time information

The ratio of answering “travel time information board” by vehicles without a car navigation system is about 34%. In regard to vehicles with a car navigation system excluding the VICS (Vehicle Information and Communication System), the ratio is about 20%, and 10% by vehicles with a car navigation system including the VICS, which provides the optimal route with consideration of the current traffic conditions. The drivers of vehicles without a car navigation system obtain travel times from travel time information board more than the drivers of vehicles with a car navigation system, because the car navigation systems in

Japan provide travel time information at any time. On the other hand, travel time information board above the road is only limited to be equipped, which can provide travel times to any drivers. The ratio of answering “a car radio” is quite low. This means the use of the car radio has been rare case nowadays in Japan. In addition, the low ratio is explained by the current roadside radio information, which does not provide travel time information during uncongested traffic conditions.

ALLOWABLE ERROR OF TRAVEL TIME INFORMATION

Consciousness on Accuracy of Travel Time Information

The result of the question, “How do you think of accuracy of the current travel time information provided by the information board above the road?” is shown in Figure 4 for a normal traffic condition and a congested condition. “Accuracy” and “rather accuracy” account for 67% for a normal condition, and “rather inaccuracy” and “inaccuracy” account for 11%. However, “accuracy” and “rather accuracy” account for only 27% for a congestion condition, and “rather inaccuracy” and “inaccuracy” account for 33%. Namely, the answer “accuracy” and “rather accuracy” for a congestion condition is 40% less than the answer for a normal condition. On the other hand, the answer “inaccuracy” and “rather inaccuracy” for a congestion condition is three times more than the answer for a normal condition. This reveals that many drivers do not believe the travel time information during traffic congestion and the current travel time information is needed to improve for providing more accurate travel times even during traffic congestion.

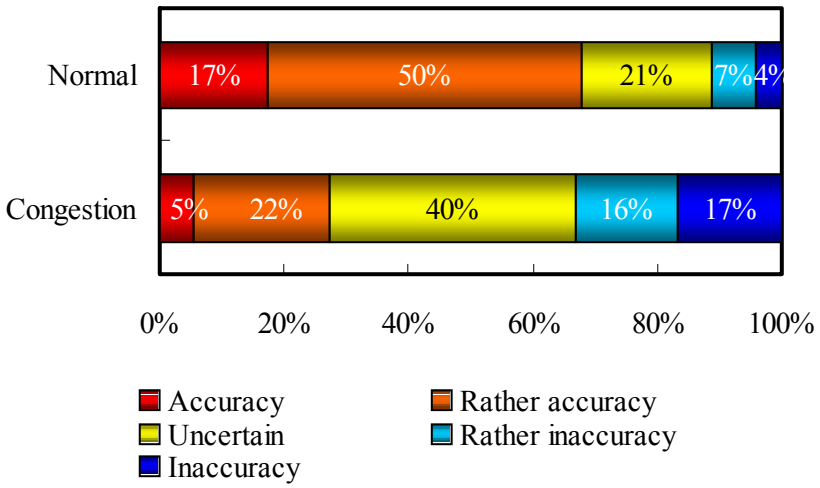


Figure 4 – Consciousness about accuracy of provided travel time information

Allowable Error of Travel Time Information

A certain question is “Travel time information of x minutes was displayed on an information board (provided travel time). However, your actual travel time was y minutes (experienced travel time). In this case, can you accept the error between the provided travel time and the

experienced travel time (y-x minutes)?" In the question, the provided travel times had three patterns of 30, 60 and 90 minutes. When x was set to 30 minutes, y was set to 20, 25, 35 and 40 minutes. When x was set to 60 minutes, y was set to 45, 50, 70 and 75 minutes. When x was set to 90 minutes, y was set to 60, 70, 80, 100, 110 and 120 minutes. The travel times x and y were randomly combined so that the influence of the combination and the order of x and y on answers can be removed. An interviewee answered the three questions with the provided travel times of 30, 60 and 90 minutes. The combination of the travel times was changed by each interviewee. The answers were evaluated by five-point scale (1 = allowable to 5 = not allowable).

Figure 5 shows the allowable ratios for errors of a provided travel time from an experienced travel time. A horizontal axis indicates the errors of the provided travel time, and a vertical axis indicates the ratio of interviewees answering "allowable" or "rather allowable" corresponding to each error. The allowable ratios for 30, 60 and 90 minute travel times are almost identical. This means that the allowable error is unrelated to the travel time and drivers evaluate an absolute error rather than a relative error of the travel time. It also reveals that approximately 80% of drivers can accept ±10 minutes error of the provided travel time. In Figure 5, a dashed line connects allowable ratios of a plus error and a minus error, in which the absolute values of the error are identical. From these lines, it can be seen that the slant of these lines is right downward. It means that drivers are more tolerant of a minus error (arriving ahead) than a plus error (arriving late).

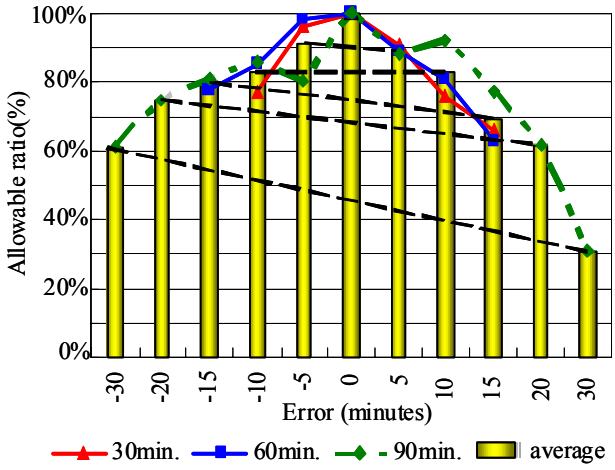
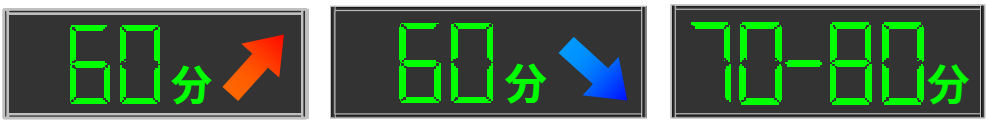


Figure 5 – Allowable ratio for travel time error

The study on the Tokyo Metropolitan Expressway also reveals that approximately 70% of drivers can accept ±5 minutes error of the provided travel time (Chang *et al.* 2004). This allowable error is smaller than one of the interurban expressway in this study, because trip distance and purpose to use such expressways are different.

INFLUENCE OF ADVANCED TRAVEL TIME INFORMATION

First, two types of advanced information are introduced in this study. One is an increase arrow and the other is a decrease arrow as shown in Figure 6. The increase arrow indicates a travel time will increase in the near future. The decrease arrow indicates a travel time will decrease in the near future. Moreover, the range of a travel time is also considered to represent uncertainty of a travel time.



(a) Increase arrow (b) Decrease arrow (c) Range of travel time

Figure 6 – Type of advanced travel time information

After the meaning of these travel time information was explained, the necessities of these information were asked for drivers. The answers were evaluated by five-point scale (1 = necessary to 5 = unnecessary). Figure 7 shows necessity of the advanced travel time information. For all of advanced information, the answer of “necessary” is major. The order of importance for the advanced information is “increase arrow”, “decrease arrow” and “range of travel time”. Consequently, it can be seen that derivers need the advanced information of an increase arrow to indicate the travel time will increase in the near future.

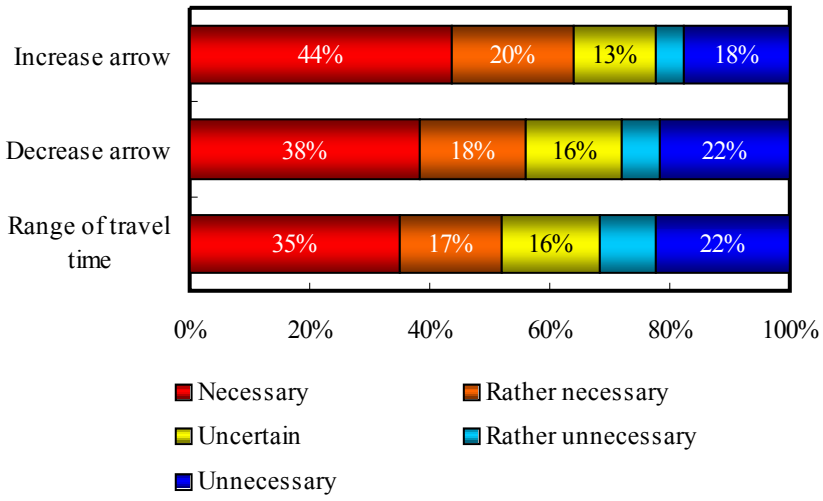


Figure 7 – Necessity of advanced travel time information

The influence of the advanced information on drivers’ route choice behaviour is grasped using a hypothetical network shown in Figure 8. There are three routes in the network. The Route 1 is the shortest from the origin to the destination. The Route 2 is a detour using the expressway. The Route 3 is also a detour using a highway. The travel time of the Route 1 under uncongested conditions was assumed to be 30, 60 or 90 minutes. When traffic congestion occurred in Route 1, the travel time was assumed to be two patterns (+15 and +30 minutes). The only travel time information and the travel time information with the additional arrow (increase or decrease) were given. The options of drivers’ route were “Route

1", "Route 1 with a break", "Route 2" and "Route 3". In addition, the travel time information was evaluated by a five-point scale (1 = useful to 5 = useless).

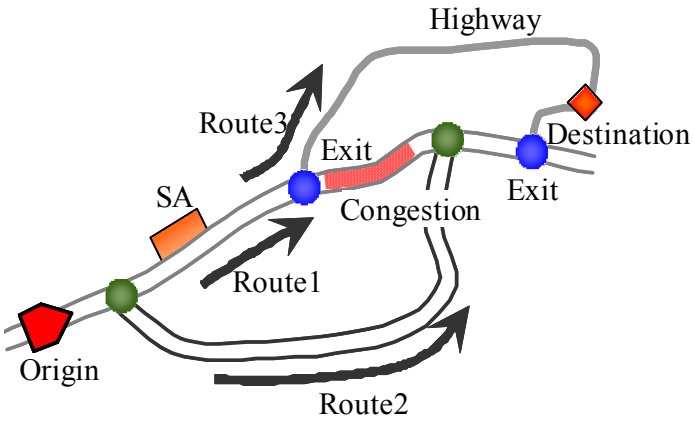


Figure 8 – Hypothetical network

Figure 9(a), 9(b) and 9(c) show ratios of interviewees changing their routes and answering that the advanced information is useful in the case with the uncongested travel time of 30 minutes, 60 minutes and 90 minutes respectively. The left vertical axis corresponding to the bar graph indicates the ratio of interviewees choosing "Route 2" or "Route 3". A right vertical axis corresponding to the line graph indicates the ratio of interviewees regarding the information as "useful" and "rather useful". A horizontal axis indicates the type of the travel time information. As a result, route choice behaviour was significantly affected by display of the increase arrow. Moreover, the ratio of information usefulness with the increase arrow is higher than one with the other information. The same results were also obtained under uncongested travel times of 60 and 90 minutes

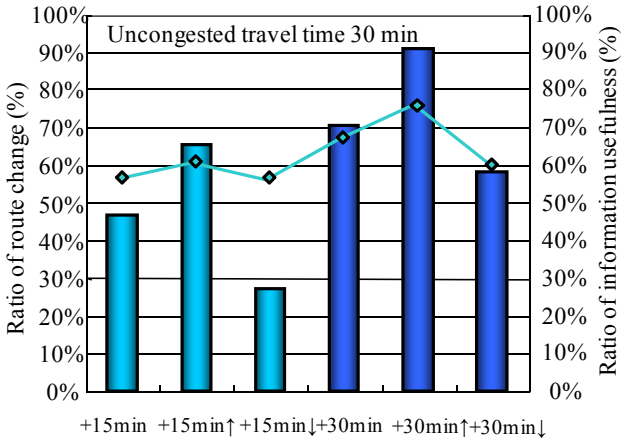


Figure 9(a) – Ratio of route change and information usefulness (30 min)

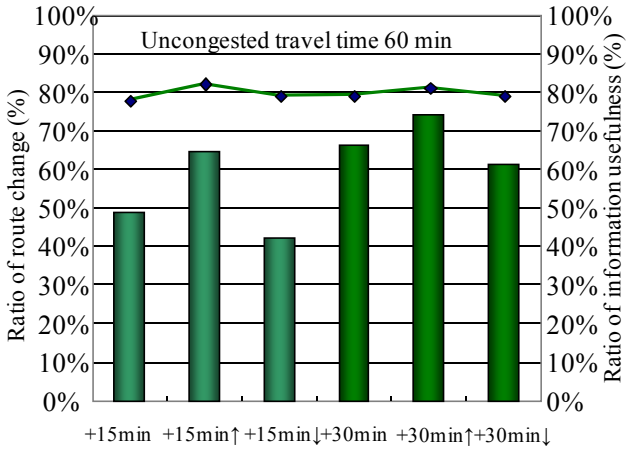


Figure 9(b) – Ratio of route change and information usefulness (60 min)

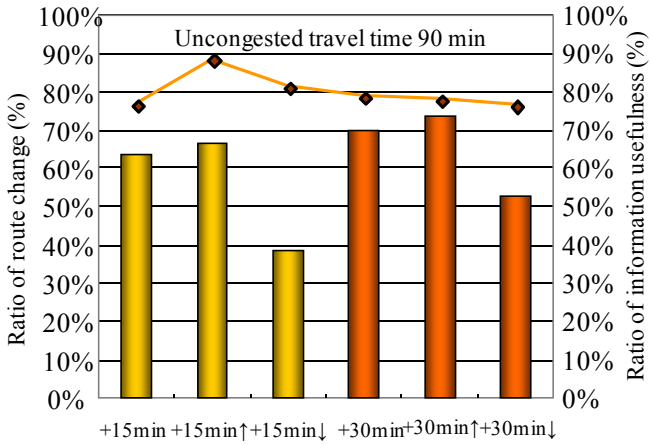


Figure 9(c) – Ratio of route change and information usefulness (90 min)

Table 2 shows the result of a disaggregate model analysis, multinomial logit model, on the drivers' route choice behaviour. The options are set to "Route 1", "Route 1 with a break" and "other routes". The model has variables of a travel time and dummy variables of the arrows.

Table 2– Attributes of interviewees and travels

Base travel time		30 min	60 min	90 min
Constant	Route 1	-0.137(-0.989)	0.004(0.019)	-0.658(-2.588)**
	with a break	-2.066(-5.897)**	-2.490(-3.538)**	-2.807(-4.262)**
Travel time		-0.042(-3.172)**	-0.038(-2.123)*	-0.018(-7.298)**
Increase arrow dummy	Route 1	-0.092(-4.980)**	-0.015(-4.668)**	-0.014(4.055)**
	with a break	0.758(2.146)	0.887(1.989)*	1.197(1.888)
Decrease arrow dummy	Route 1	0.938(5.504)**	0.813(7.477)**	0.428(1.984)*
	with a break	0.981(7.845)**	0.819(2.029)**	0.775(2.982)**
ρ^2		0.256	0.340	0.255
Hit ratio (%)		57.65%	59.65%	60.73%

*:5%significant, **:1% significant

From the estimated parameters, it is found that the display of the increase arrow reduces the use of "Route 1" and the display of the decrease arrow increases the use of "Route 1 with a

break". As a result, the influence of the displaying the advanced travel time information on drivers' route choice behaviour decreases in proportion to the uncongested travel times.

CONCLUSION

In this paper, the questionnaire survey was conducted at SA and PA on expressways aiming to catch drivers' consciousness for travel time information on an expressway. From the survey, it reveals that approximately 80% of drivers accept ±10 minutes error of a provided travel time from an actual travel time. Moreover, the advanced travel time information has a considerable influence on drivers' route choice behaviour. In particular, the display of the increase arrow reduces the use of the route in which the travel time will increase. Consequently, it is clarified that the display of the arrow has possibility to relieve traffic congestion effectively.

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