An Analysis of Effects of Trend Information upon Route Choice Behavior by In-Laboratory Experiment

Mitsuhisa Tanaka [*1] Nobuhiro Uno [*2] Fumitaka Kurauchi [*3] Yoongho Ahn [*1]
Graduate School of Engineering, Kyoto University [*1]
(C Cluster, Kyotodaigaku Katsura, Nishikyo-ku, Kyoto, 615-8540, Japan, +81-75-383-3237, m.tanaka@trans.kuciv.kyoto-u.ac.jp, ahn@trans.kuciv.kyoto-u.ac.jp)
Graduate School of Management, Kyoto University [*2]
(C Cluster, Kyotodaigaku Katsura, Nishikyo-ku, Kyoto, 615-8540, Japan, +81-75-383-3224, uno@trans.kuciv.kyoto-u.ac.jp)
Department of Civil Engineering, Gify University [*3]
(1-1 Yanagido, Gifu, 501-1193, Japan, +81-58-293-2447, kurauchi@gifu-u.ac.jp)

This study focuses on the possibility that providing the information on short-term trend of traffic condition (trend information) with exiting travel time information might affect the decision-makings of travelers and lead to the enhancement in traffic control by information provision. As an initial step to confirm the effectiveness of trend information, this study conducts the in-laboratory experiment to obtain a kind of panel data of route choices under the provision of information. In this study the parameters of Mixed Logit Model are estimated in order to statistically analyze the influences of trend information upon decision-makings of respondents considering the accuracy of information. The basic findings obtained in this study are as follows. 1)There is a strong possibility that the trend information may significantly affect the decision-makings on route choices of respondents. 2)The influence of information upon the decision-makings of respondents may depend upon the accuracy of both travel time information and trend one. 3)Judging from the estimated parameters of standard deviation of travel time information, there must be the heterogeneity in the sensitivity toward the travel time information among the respondents.

Keywords: *route choice behavior, travel time information, trend information, in-laboratory experiment*

1. Introduction

1.1. Motivation and Purpose

Most of travelers using information usually today may not choose the route whose actual travel time is the shortest because the travel time information provided now is not highly accurate predicted information but a sort of descriptive one. Moreover, it may happen that the traffic condition become worse by the information provided [1]. Concerning the descriptive information, this kind of information does not include the driver's response to information provided. In other words, there is a lag between the point in time that descriptive information refers to and the point in time that drivers actually travel along the route, and hereby the overconcentration of travelers affected by information may occur.

That is the reason why we focus on the provision of additional information with the existing descriptive information in order to relax the accuracy problem of descriptive information on travel time. The ideal solution is to offer precise predicted information to travelers, but in reality it is difficult to predict the traffic condition accurately. However, it is able to predict short-term traffic condition to some extent of accuracy, and accordingly adding the trend information which expresses the short-term variation of traffic condition by arrows on VMS (Variable Message Sign) board, has been put into practical use in Metropolitan Expressway of Tokyo. There is a possibility that providing the information on short-term trend of traffic condition (abbreviated here-in-after to "trend information") might lead to not only improvement in service for travelers but also enhancement in traffic control by information provision.

The two goals of providing travelers with trend information are assumed:

1) to relax the problem of the accuracy of descriptive information on travel time by providing the trend information, and
2) to relax the overconcentration of traffic onto a certain route by making travelers' route choices diverse by providing trend information in addition to descriptive information.

This study analyzes the way to provide information which has been deployed actually in few areas. Also this study is aimed at analyzing the influence of accuracy of information upon the traveler's decision-making on route. Therefore, it is appropriate to collect data on route choice under provision of trend information by in-

laboratory experiment. Considering the progress of computer technology today, such an experimental approach using simulator becomes popular. Mahmassani and Liu[2] analyzed the influence of pre-trip information and en-route information to the drivers' route choice by using experiment. Bonsall and Merrall[3] analyzed drivers' reaction when they get accident information by route choice simulator. There are some studies which tried to analyze the relation between the accuracy of information and drivers' behavior. Bonsall[4] express that the drivers' compliance with information depends on their knowledge about the network and the accuracy of information they get.

The authors have studied the influence of trend information on traveler's route choices. Uno et al.[5] show that trend information relaxes the traffic congestion of the specific route and can improve the reliability of network by a simple network simulation based on hypothetical route choice behavior. In order to analyze the effect of trend information on route choice behavior more practically, a questionnaire survey was conducted for the actual users of intercity expressway [6].

In addition, Ahn et al. conducted some cases of PC-based experiments of route choice behavior under provision of trend information, in which the analytical attentions can be paid to the effects of both information accuracy and travel experiences on decision-making of travelers [7]. This study suggests that the trend information might affect route choices of travelers especially in the case where the difference in travel time information among the routes is relatively small. Also, the effects of travel experience on route choice tend to be relatively strong, if the information provided is less accurate.

While this study can be regarded as the successive one of Ahn et al. and uses the same data obtained from the in-laboratory experiment, the analytical attention is mainly paid to the condition where the trend information might give the relatively strong influence to decision-making of travelers explicitly considering the accuracy of information. Also this study attempts to analyze the heterogeneity of respondents toward the information provided in their decision-making of route choice.

1.2. Potential of Information on Short-term Trend of Traffic Condition

In general, in terms of the point in time to which information refers, the traffic information can be classified into three categories:

1) Historical Information,
2) Descriptive (or Present) Information, and
3) Predictive Information.

The historical information can convey the statistics estimated from accumulated data on traffic condition to the travelers. The statistics include average and maximum values of travel time, probability of traffic jam, probability that a traveler can reach his / her destination within a threshold in time and so on.

Provision of descriptive information is the most conventional way of providing traffic information, if the traffic detectors are installed and operated along the roadways. It is assumed that a route is divided into several blocks with a certain length, and a traffic detector to measure traffic volume, occupancy and speed is installed in every block. The following equation gives the descriptive information on travel time.

$$T^D(t) = \sum_{j=1}^{J} L_j / v_j(t-1) \qquad (1)$$

$T^D(t)$ represents the descriptive information on travel time at time-period t, L_j represents the length of block j, and $v_j(t-1)$ indicates the velocity of block j at time-period $t-1$.

Obviously the equation (1) does not include the driver's response to information provided. In other words, there is a lag between the point in time that descriptive information refers to and the point in time that drivers actually travel along the route. Accordingly, there is a possibility that provision of descriptive information might lead to the concentration of traffic on the path of which travel time according to information is minimal and also might cause hunting phenomena [8].

While it is more desirable for travelers to obtain predictive traffic information, it is difficult for traffic information system to provide *accurate* predictive information. In order to provide accurate information, the information system must consider the traveler's response to information provided in generating the predictive information on travel time. But the traveler's response to information has not been completely clarified yet.

This study proposes a practical way that provides travelers with the information on short-term trend of travel time in addition to the descriptive one. The information on short-term trend (trend information) is regarded to convey the temporal changes in traffic condition on road network to drivers easily. There is a possibility that the travelers might pay attention to the trend of travel time if the difference in travel time according to descriptive information between paths is relatively small. And hereby, it is expected that providing drivers with trend information may enhance the rational decision-making on route of drivers and prevent the traffic from concentrating on a certain route. Focusing on the access-controlled roads including intercity and urban expressway, it might be technologically feasible to predict the short-term trend of traffic jam and travel time and to provide drivers with this kind of information, because the places at which traffic can enter and exit are limited and the huge amount of data are obtained through the detectors installed along the road.

2. Design of In-Laboratory Experiment

The design of in-laboratory experiment about route choice behavior is explained in this section.

2.1. Network

This study adopts the simplest network composed of 1 OD and 2 routes, where each respondent can choose his / her route freely. Since this study intends to collect the data about stated preferences of respondents on route choice by the computer-based in-laboratory experiment, the network adopted here should be simplified in order to make the respondents understand clearly the traffic condition on each route. As shown in Figure 1, there is network to be used in this experiment. Route 1 has 15Km of distance from origin to destination. On the other hand, Route 2 has 20Km of distance and looks like a kind of detour route for the Route 1.

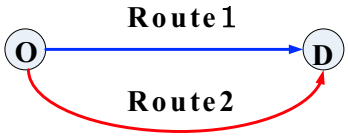

Figure 1 object network

2.2. Information provided

It is assumed that each case of experiment is composed of three phases characterized by the amount of information provided and each phase consists of twenty iterations to collect the stated preference data from respondents. In other words, each respondent is required to reply his / her preference on route choice sixty times in total. In-laboratory experiment consists of three phases below.

Phase1: no information is given.

Phase2: only travel time information is given.

Phase3: both travel time and trend information is given, as shown in Figure 2.

Travel time & Trend Information	
Route1	Route2
25 ↗	30 ↘

Figure 2 Example of information

2.3. Procedure of Experiment

The procedure of in-laboratory experiment is shown below.

Step 1: The experimenter explain the respondents the objectives and outlines of experiment including the studied network and the definition of information. Also the experimenter reminds the respondents not to discuss anything related to their reply to the question with other respondents.

Step 2: The respondents predict the travel time of each route considering their travel experience and / or provided information and choose their route based on the predicted travel time. In Phase 1, each respondent predict his / her travel time considering only travel experience because no traffic information is given to the respondent.

Step 3: The actual travel time of the route chosen by the respondent are provided as his / her travel result.

Step 4: In order to make a clear difference between the travel result to be accumulated as the experience of the respondent and the just information provided, the respondent is required to input his / her route chosen and its actual travel time into the in-laboratory experiment system to confirm his / her travel result.

The respondent is required to repeat steps 2 to 4 until reaching the predetermined number of iterations (60 times).

Step 5: After the route choice experiment, the respondent is required to answer his / her personal attributes in the questionnaire. The items of the questionnaire are gender, age, occupation, retainment of driving license, frequency of vehicle usage, ownership of his/ her private car and impression of this experiment.

2.4 Information settings and its validity

2.4.1 Settings of actual travel time. In the in-laboratory experiment, it is important to generate a set of actual travel times and the corresponding travel time information. As mentioned above, an analytical attention is also paid to the relation between accuracy of information and the route choice of the respondent. In that sense, easy to control the accuracy of information is one of important aspects for deigning the experiment. Accordingly, this study generate the actual travel times, which are given to the respondents as the travel results firstly. Then travel time information is generated by adding the random number to control the information accuracy. Here is a brief explanation about how to generate actual travel time below.

A distribution of actual travel time is assumed to be represented by a combined two exponential distributions, because of making a clear difference in travel time between congested condition and non-congested one. The distributions of actual travel times of Route 1 and Route 2 are generated separately considering the route characteristics including length and capacity of each route. The shortest actual travel time of Route 1 is 15 minutes and λ of exponential distribution of Route 1 is 0.05. And the shortest actual travel time of Route 2 is 20 minutes and λ of exponential distribution is 0.01. The distributions of actual travel times of Route 1 and Route 2 are shown in Figure 3.

As shown in Figure 3, Route 2 is assumed to be a more stable route in terms of (fluctuation in) travel time than Route 1. However, the probability of arriving at the destination within thirty minutes of Route 1 is higher than that of Route 2. In other words, Route 1 is regarded as the route which a risk-taker tends to use.

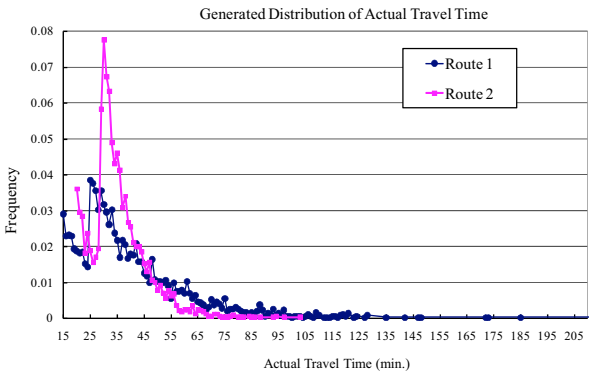

Figure 3 Distribution of actual travel time generated

2.4.2 Settings of travel time information. The travel time information is assumed to be generated as a normal random number of which average value is the same as the actual travel time determined in advance. The accuracy of travel time information can be controlled by the Standard Deviation (SD) of the normal random number. In this experiment, it is assumed that Standard Deviations of Highly accurate travel time information and less accurate information are five minutes and fifteen minutes respectively. Figure 4 shows the difference between the travel time information generated and the actual travel time of Route 1. It can be found that the variations of highly accurate information and Less accurate one is drastically different.

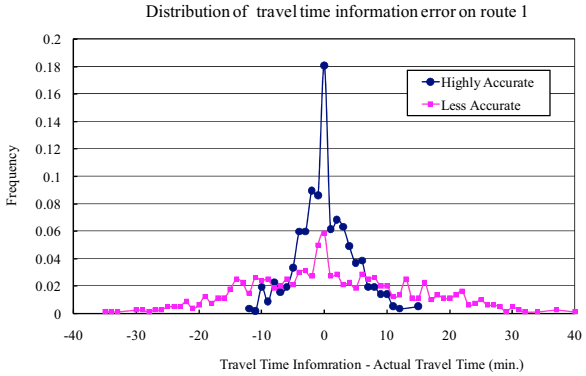

Figure 4 Difference between travel time information and actual travel time of Route 1

2.4.3 Settings of trend information. In this experiment, the trend information is classified into three different trends of travel time indicated by the directions of arrow. A right-up arrow means that travel time is expected to increase. Horizontal arrow means that travel time is expected to be almost stable. And right-down arrow indicates that travel time is expected to decrease. The correct trend (direction of arrow) is determined by subtracting travel time information from actual travel time. If the subtraction of travel time information from actual travel time becomes positive, travel time will increase compared with the travel time according to information and vice versa. The trend information is assumed to be generated by a uniform random number. It is assumed that the probability that the trend information suggest the correct change in travel time becomes 80% and 20% in the highly and less accurate cases respectively. Also the horizontal arrow is provided only when the difference between actual travel time and travel time information is within ±1 minute.

Finally, settings of the trend information are validated on the basis the accuracy of trend information actually provided in the experiment. The rate of correct trend information provided is shown in Table 1. Table 1 suggests that there are only slight differences between the probability that the trend information suggest the correct change in travel time determined in advance and the rate of correct information provided in the experiment actually.

Table 1 Rate of correct trend information provided

	Rate of correct information provided
Highly accurate case	75%
Less accurate case	29%

2.5. Cases of Experiment

This study conducts three cases of in-laboratory experiment characterized by the accuracy of information.

1) HH case: the respondents can utilize both Highly accurate travel time information and Highly accurate trend information.
2) LH case: the respondents can utilize Less accurate travel time information and Highly accurate trend information.
3) LL case: the respondents can utilize both Less accurate travel time information and Less accurate trend information only.

Especially, this study pays the attention to LH case and examines in particular potential of the trend information. In the actual environment, the travel time information provided can be regarded as a type of descriptive information. Accordingly, it is difficult to expect that the accuracy of travel time information is high, and the trend information is expected to have the potential to mitigate the drawbacks of descriptive information mentioned at the section 1.2.

The number of respondents in each case is 20, and the most of them are male students and have their driving license. Although it is difficult for us to tell that the respondents here represent a population of general drivers, the data obtained from the respondents are regarded to be effective for an initial step to analyze the influence of trend information upon the decision-making of respondents.

3. Basic Analysis of Route Choice of Respondents

3.1. Preliminary analysis of route choice of respondents

In this subsection, the analytical attention is mainly paid to how the respondents choose their route in the in-laboratory experiment. In order to preliminarily analyze the route choice under the provision of travel time information and trend information, this study adopts three indices shown below:

1) rate of compliance of respondents with travel time information,
2) rate of compliance with travel time expected by respondent, and
3) choice rate of route with actually shorter travel time.

The first and second indices are used for analyzing the rules of respondents for their route choice under the influence of information. The third index is used for confirming whether each respondent can do the rational route choice or not from the viewpoints of his / her travel results. Especially, this study focuses on the diversity of route choices of respondents, and hereby the indices above are shown for each respondent in Figures 5 to 7. Figures 5 to 7 show three indices mentioned above for LH case.

3.1.1. Rate of compliance with information. The rate of compliance of respondents with travel time information is defined as the percentage of the choices of route with the shorter travel time suggested by the information for each respondent for all the iterations of route choice experiment (Figure 5). Judging from Figure 5, most of the respondents seem to choose the route of which the travel time according to information is shorter. In other words, most of respondents seem to comply with the travel time information. Simultaneously, the rate of compliance with travel time information reaches only 50 to 60% for some of the respondents. This result implies that some of the respondents might tend to depend on not only travel time information but also other factors such as travel experience, trend information and so on. In terms of the compliance with the travel time information, there might be a slight heterogeneity in route choice among the respondents.

3.1.2. Rate of compliance with expected travel time. The rate of compliance with travel time expected by respondent is defined as the percentage of choices of route with the shorter travel time expected by the respondent (Figure 6). Figure 6 suggests that the most of the respondents tend to follow their own prediction of travel time, when they make their decisions on the route choices. In other words, the route choices done by most of the respondents are rational and not contradictory with their travel time prediction.

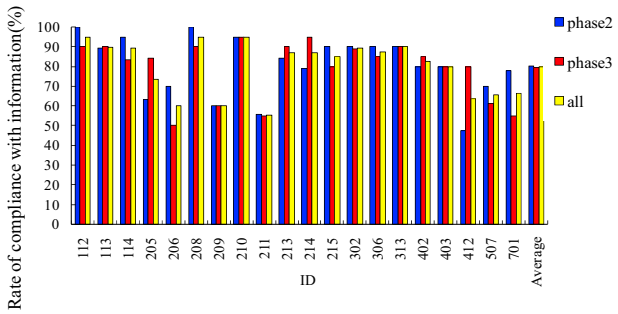

Figure 5 Rate of compliance with travel time information (LH case)

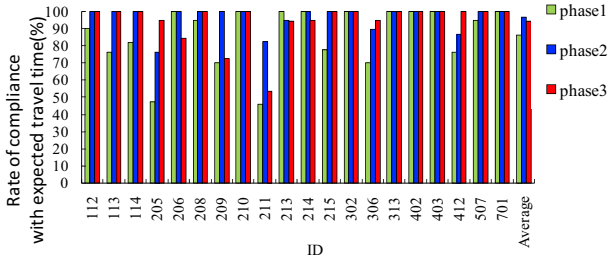

Figure 6 Rate of compliance with expected travel time (LH case)

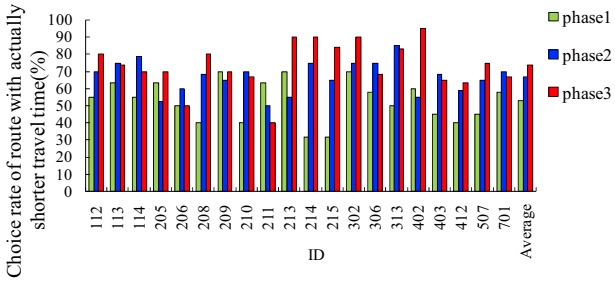

Figure 7 Choice rate of route with actually shorter travel time (LH case)

3.1.3. Choice rate of route with actually shorter travel time. The choice rate of route with actually shorter travel time is defined as the percentage of choices of route with shorter travel time in actual for all the iterations of route choice experiment (Figure 7). In general, the choice rate of route with actually shorter travel time tend to be smaller than the rate of compliance of respondents with travel time information, because the less accurate travel time information is provided in LH case. If we make a comparison in the choice rate of route with actually shorter travel time among phases 1, 2 and 3, the choice rate of phase 3 seems to be better than that of phase 1 and 2. This result suggests that the provision of trend information is expected to assist the decision-making of respondents properly.

3.2. Relation between travel time information and rate of route choice

In order to analyze the relationship between information provided and route choices of respondents

statistically, a kind of regression analysis is applied to the choice rate of route 1. The difference in travel time information between route 1 and route 2 is used as the explanatory variable of regression model.

3.2.1. Relation between choice rate of route1 and accuracy of travel time information. Choice rate of route1 is calculated by equation (2).

$$P_{R1}(t) = \frac{100 n_{R1}(t)}{n_{R1}(t) + n_{R2}(t)} \qquad (2)$$

t : Difference in travel time(travel time of route1 - travel time of route2, (min.))

$P_{R1}(t)$: Choice rate of route1 when the difference in travel time is t

$n_{R1}(t)$:The total number of respondents who choose route1 when the difference in travel time is t.

$n_{R2}(t)$: The total number of respondents who choose route2 when the difference in travel time is t

In order to statistically compare the relation between route choice rate and travel time information provided among both the phases and the cases, the logistic regression analysis was applied for the choice rate of route 1 as the dependent variable. Figures 8, 9 and 10 show both the actual choice rate of route 1 and the estimated logistics curves of LH, HH and LL cases respectively. In general, if the travel time information affects the route choices of the respondents strongly, the estimated logistic curve of choice rate of route 1 tends to be steeper and located around the vertical axis.

If the comparisons in the slopes of logistics curves are made between phase 2 and phase 3 for all three cases, the slopes of phase 2 commonly tend to be a little steeper than that of phase 3. It implies that the provision of trend information might lead to a little reduction in influence of travel time information upon route choices of respondents, because the respondents can obtain the trend information in phase 3 only.

Among the three figures, the slopes of estimated logistic curve are the steepest and R^2 is the highest in Figure 9. In addition, R^2 is the lowest in Figure 8 and this result implies that the factors other than travel time information might affect the route choice of respondents strongly in LH case. In other words, the respondents seem to depend more strongly upon the trend information in the case where the travel time information provided is less accurate.

Judging from the discussions above, there is a strong possibility that the influences of both travel time information and trend information upon the respondent's decision-making might be affected by the accuracy of information. In the next section, these influences are statistically analyzed in detail by applying the mixed logit model for the decision-making on route of the respondent.

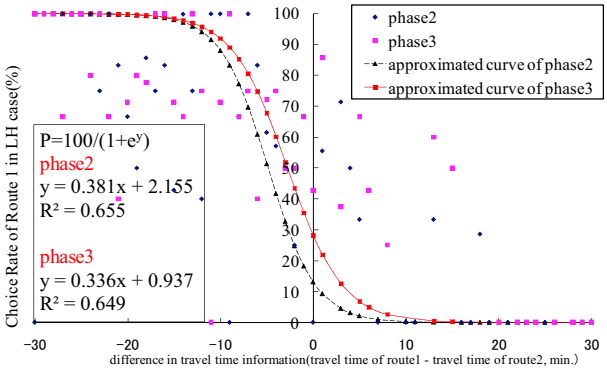

Figure 8 Choice rate of route1 in LH case

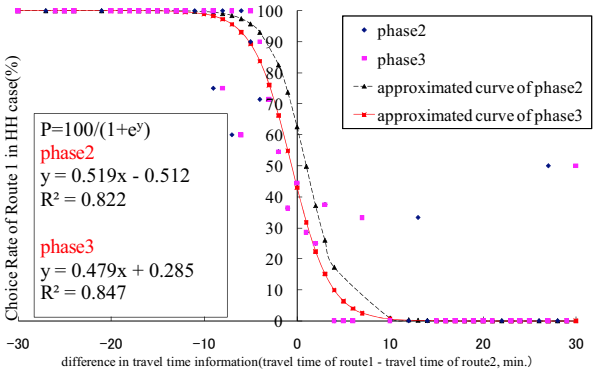

Figure 9 Choice rate of route1 in HH case

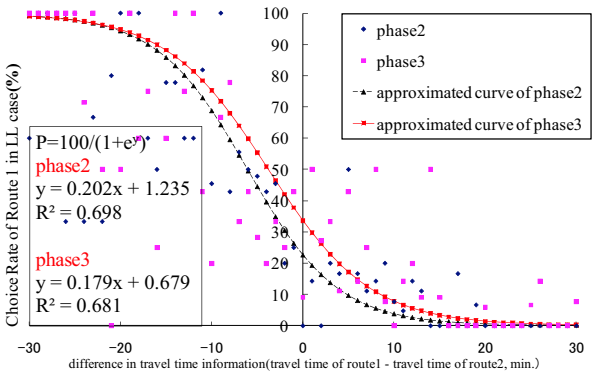

Figure 10 Choice rate of route1 in LL case

3.2.2. Analysis of dilemma case. In this study, a dilemma case in terms of information is defined; in the dilemma case, the great and small values of travel time information between routes do not coincide with the increase and decrease in travel time given by the trend information. For example, the travel times according to the information of route 1 and route 2 are 25 and 30 minutes, respectively, and the trend information suggests that travel time of route 1 might increase and that of route 2 might decrease, as shown in Figure 2. This is a typical dilemma case in terms of information provided.

Especially, it is reasonable to suppose that the trend information might affect the decision-making of respondent in the relatively strong manner in the

dilemma case with a small difference in travel time information between route 1 and route 2.

Figure 11 shows the choice rate of route 1 in both the dilemma case and the non-dilemma case in terms of information provided. In Figure 11, the choice rates of route 1 in the dilemma case and the non-dilemma one are expressed by solid lines and dashed lines, respectively. Clearly, the choice rate of the non-dilemma case is different from that of the dilemma case, and there is a monotonous decreasing relation between the difference in travel time information and the choice rate of route1 in all the non-dilemma cases.

On the other hand, it seems that the most of respondents tend to be affected by the trend information in all the dilemma cases shown in Figure 11. It is found clearly that the choice rate of route 1 drastically become large even when the travel time information of route1 is longer than of route2 in all the dilemma cases and vice versa. Especially, it seems that the route choices of respondents in LH case tend to be less sensitive to the travel time information than those in LL and HH cases.

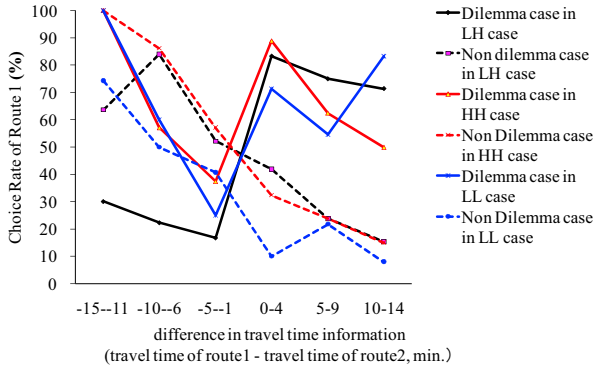

Figure 11 Choice rate of route1 in dilemma case

Judging from the discussions above, it can be said that influence of trend information upon the decision-makings of respondents in the dilemma case might stronger than that in the non-dilemma case. Especially, the trend information might affect more strongly in the case where the respondents can obtain the less accurate travel time information and the highly accurate trend information.

4. Route Choice Model

Based on the preliminary analysis of the route choices under provision of both travel time information and trend one, the following questions are raised here:

1) whether the trend information may significantly affect the decision-makings of respondents or not,
2) whether the influence of information provided upon the decision-makings of respondents may depend on the accuracy of information or not, and,
3) whether the heterogeneity in decision-makings on route choice among the respondents can be confirmed or not.

In this section, we try to give the answers to these questions above through estimating the Mixed Logit Model for the observed route choices.

4.1. Variables and dilemma dummy

In order to verify the statistical significance of the hypotheses above, this study applies the discrete choice modeling approach to analyze the route choices of respondents observed in the in-laboratory experiment. The route choice data used in this study can be regarded as a kind of panel data obtained from the limited number of respondents. Accordingly, there is a possibility that the correlation between error terms in the discrete choice model might exist. Also, one of the objectives of this study is to verify the heterogeneity in the route choice behavior under the provision of information. In general, it is expected that the response toward information provided are different among the respondents. Therefore, this study adopts the Mixed Logit Model, in which the heterogeneity in decision-making among individuals can be explicitly considered by the random parameters. In other words, the Mixed Logit Model has a capability to express the heterogeneity in the preferences of respondents as some continuous probability distribution. If the estimated standard deviation (SD) of parameter related to the information can be regarded as statistically significant, it can be concluded that there is a strong possibility of the heterogeneity in response to the information provided among respondents. The error term is assumed to follow Gumbel distribution in this model.

It is assumed that this model includes the travel time information and the dummy variable to express influence of trend information as the explanatory variables. The variables of travel time information in three phase and three case are treated as different variables in order to analyze influence of information provided upon the decision-makings of respondents considering the software aspects of information such as the type, the amount and the accuracy of information.

The influence of trend information is evaluated by the parameters of dummy variables called dilemma dummy variable.

In this study, two types of dilemma case in terms of information provided are taken into explicit consideration, and there are two corresponding dilemma dummies: d1 and d2.. The dilemma dummy variable d1 becomes one, in the case where the travel time according to information of route1 is shorter than that of route2, and the trend information suggests both increase in travel time of route 1 and decrease of route 2. The dilemma dummy variable d2 becomes one, in the case the travel time according to information of route1 is longer than that of route2, and the trend information suggests both

decrease in travel time of route 1 and increase of route 2. In other situations, both dilemma dummy variables must be zero.

4.2. Estimation of Mixed Logit Model

The Mixed Logit Model is defined by the equation (3), which express of the probability that alternative *i* is chosen by individual *n*.

$$P_{in} = \int \prod_{t=1}^{T} \left[\frac{\exp\left(\boldsymbol{\beta}^t \mathbf{x}_{in} + \theta_{in}\right)}{\exp\left(\boldsymbol{\beta}^t \mathbf{x}_{1n} + \theta_{1n} + \boldsymbol{\beta}^t \mathbf{x}_{2n} + \theta_{2n}\right)} \right]^{\delta_{\text{int}}} f\left(\boldsymbol{\theta}/\boldsymbol{\Omega}\right) d\boldsymbol{\theta} \ , \ i = 1,2 \quad (3)$$

$\boldsymbol{\beta}$: parameter vector to be estimated,

$\mathbf{x}_{in}$: explanatory variable to define the utility of alternative *i* for respondent *n*,

θ_{in} : dummy parameter of alternative *i* for respondent *n*,

$f\left(\boldsymbol{\theta}/\boldsymbol{\Omega}\right)$: probability density function of $\boldsymbol{\theta}$ conditional to $\boldsymbol{\Omega}$,

δ_{int} : if the choice at *t*-th iteration of respondent *n* is alternative *i*, δ_{int} =1, otherwise 0,and

T : the total number of iterations of experiment for each respondent.

Table2 shows the estimated parameters of the Mixed Logit Model. First of all, the adjusted ρ^2 reaches 0.462, and hereby it can be said that it is effective for us to discuss the various characteristics of route choices observed in the in-laboratory experiments based on the estimated parameters shown in Table 2.

It can be found that all the parameters to express the influence of travel time information including their averages and standard deviations are statistically significant. Accordingly, it can be concluded that the travel time information gives the significant influence to the decision-makings of respondents and there must be the heterogeneity in the sensitivity toward the travel time information among the respondents. On the other hand, all the estimated standard deviations of dilemma dummies representing the influence of trend information are statistically insignificant. Accordingly, based on the results obtained from the laboratory experiment, we do not confirm the heterogeneity in the sensitivity toward the trend information among the respondents.

If our attention is paid to the change in absolute value of estimated average of travel time information between phase 2 and phase 3, LH case seems to take the largest change. It implies that the route choice mechanisms of respondents might change most drastically in LH case. Focusing on the estimated parameters of the dilemma dummy variables, the averages of estimated parameters only for LH and HH cases are statistically significant. In other words, the less accurate trend information provided in LL case seems not to affect the decision-makings of respondents significantly. Especially, the absolute values of dilemma dummies in LH case are larger than those in HH case. Judging from the analyses above, it can be said that providing the respondents with the trend information during phase 3 may lead to the most drastic change in their route choice mechanisms in LH case. Therefore, there is a possibility that the provision of relatively accurate trend information might affect strongly the travelers obtaining the less accurate travel time information.

Table 2 Results of Estimation of Mixed Logit Model

Variables		parameter	t-value
Constant term	Average	-0.17	*-1.41
	Standard deviation	0.86	6.03
Travel time info. of phase3 on LH case	Average	-0.29	-5.38
	Standard deviation	0.12	4.45
Travel time info. of phase3 on HH case	Average	-0.19	-5.16
	Standard deviation	0.07	2.32
Travel time info. of phase3 on LL case	Average	-0.17	-5.28
	Standard deviation	0.07	4.58
Travel time info. of phase2 on LH case	Average	-0.15	-4.57
	Standard deviation	0.09	3.23
Travel time info. of phase2 on HH case	Average	-0.28	-4.89
	Standard deviation	0.13	4.33
Travel time info. of phase2 on LL case	Average	-0.17	-5.08
	Standard deviation	0.09	3.00
Dilemma dummy1 on LH case	Average	-4.73	-4.42
	Standard deviation	1.76	*1.93
Dilemma dummy2 on LH case	Average	3.90	4.59
	Standard deviation	0.25	*0.13
Dilemma dummy1 on HH case	Average	-1.09	*-1.59
	Standard deviation	1.11	*0.74
Dilemma dummy2 on HH case	Average	2.23	3.43
	Standard deviation	0.73	*0.51
Dilemma dummy1 on LL case	Average	-2.21	-1.98
	Standard deviation	2.11	*1.94
Dilemma dummy2 on LL case	Average	1.38	*1.72
	Standard deviation	2.28	*1.68
Number of observation		1800	
Log likelihood function		-661.92	
Lmax		-1247.66	
ρ^2		0.469	
Adjusted ρ^2		0.462	

*: insignificant, as the significant level is 5%

5. Conclusion

This study focuses on the possibility that providing the information on short-term trend of traffic condition (trend information) with exiting travel time information might affect the decision-makings of travelers and lead to the enhancement in traffic control by information provision. As an initial step to confirm the effectiveness of trend information, this study conducts the in-laboratory experiment to obtain a kind of panel data of route choices under the provision of information. In this study the parameters of Mixed Logit Model are estimated in order to statistically analyze the influences of trend information upon decision-makings of respondents considering the accuracy of information. The basic findings obtained in this study are as follows:

1) There is a strong possibility that the trend information may significantly affect the decision-makings on route choices of respondents. Especially, the trend information may give the relatively strong influence to the respondents in the dilemma case, where the great and small values of travel time information between routes do not coincide with the increase and decrease in travel time given by the trend information.
2) The influence of information upon the decision-makings of respondents may depend upon the accuracy of both travel time information and trend one. Especially, in the case where the less accurate travel time information is provided to the respondents, the accurate trend information may give the strong influence to the decision-makings on route choices of respondents.
3) Judging from the significance in the estimated parameters of standard deviation of travel time information, there must be the heterogeneity in the sensitivity toward the travel time information among the respondents.

The further research subjects are explained below.

1) It seems that the jam information showing the location and the length of jam is more general in the traffic information system. Accordingly, it is necessary for us to analyze the influence of trend information on traffic jam upon the decision-makings of travelers.
2) In order to analyze the interaction between information, route choice behavior and traffic condition on network, the case studies using the traffic simulation into which the route choice model built in this study is incorporated.

References

[1] Arnott, R, de Palma, A. and Lindsey, R: "Does Providing Information to Drivers Reduce Traffic Congestion?", Transportation Research-A, 1991

[2] Mahmassani H. S. and Liu Y. (1995): "Commuter Pre-Trip Decisions Route Choices and En-Route Path Selection under Real-Time Information: Experimental Results", Proceedings of the Second World Congress on Intelligent Transport Systems, pp. 1860-1864

[3] Bonsall P. and Merrall A. C. (1995): "Analysing and Modelling the Influence of Roadside Variable Message Displays on Drivers' Route Choice", Proceedings of the 7th World Conference on Transport Research, Volume 1, pp. 11-25

[4] Bonsall, P. (1992): "The Influence of Route Guidance Advice on Route Choice in Urban Networks", Transportation, 19, pp. 1-23

[5] Uno, N., Iida, Y. and Kawaratani, S: "Effects of Dynamic Information System on Travel Time Reliability of Road Network, Traffic and Transportation Studies", ASCE, 2002

[6] Uno, N., Sugimoto, I., Iida, Y., Yamada, N. and Nakagawa, S. : An Analysis of Effects of Traffic Information for Expressway with Multiple Route Using SP Survey, Infrastructure Planning Reviews, Vol.21 No.4,pp. 941-949, 2004 (in Japanese).

[7] Ahn, Y. Uno, N., Kurauchi, F. and Mikami, K. : "An Experimental Analysis of Effects of Information about Short-term Trend of Traffic Condition upon Route Choice Behavior", presented at IATBR in Kyoto, 2006

[8] Oguchi, T. Satoh, M. Katakura and S. Shikata (2003). Analysis of traffic congestion and route choice behavior influenced by traffic information. International Journal of ITS Research, Vol. 1, No. 1, 75-82.

Mitsuhisa Tanaka is a master course student at Department of Urban Management of Kyoto University. He received his Bachelor Degree from Kyoto University in 2007. His research zunder provision of dynamic information.

Nobuhiro Uno is an Associate Professor at Kyoto University. He received his Doctor of Engineering Degree from Kyoto University in 1997. His research interests include travel behavior under provision of information, traffic control for urban expressway and microscopic analysis of vehicular behavior using video image data.

Fumitaka Kurauchi is an Associate Professor at Gifu University. He received his Doctor of Engineering Degree from Kyoto University in 2002. His research interests include travel behavior under provision of dynamic information, transit assignment models and network reliability analysis.

Yoongho Ahn is a researcher at Kyoto University. He received his Doctor of Engineering Degree from Kyoto University in 2008. His research interest includes route choice behavior under provision of dynamic information.

Received date: April 15 2008
Received in revised form: June 13 2008
Accepted date: June 13 2008
Editor: Yasuo Asakura