Route Choice and Information Use: Initial Results from Simulation Experiments

KENNETH M. VAUGHN, PRASUNA REDDY, MOHAMED A. ABDEL-ATY, RYUICHI KITAMURA, AND PAUL P. JOVANIS

Computer-based simulation experiments were designed and conducted utilizing 100 regular commuters from the Sacramento, Calif. region. Computer-based simulation was used to create a hypothetical traffic network and as a tool for collecting dynamic route choice data. Dynamic route choice data under the influence of incident information, en route guidance, pretrip guidance, and congestion information were collected for a sequence of 20 simulated trial days for each participant. A fractional factorial experimental design was used in the experiment. The experimental treatments included the type of information that subjects received, as well as personal characteristics of the subjects themselves. An analysis of the experimental treatments on subjects' accuracy perceptions, information effects on travel decisions, and consumer demand and information system valuation was performed utilizing analysis of variance and regression techniques with corrections for heteroskedasticity. Study results were compared with previous survey and simulation research. The findings indicate that there are significant differences between the individual characteristics that influence drivers' preferences about how they receive information and the characteristics that influence drivers' travel choices in response to receipt of such information. Results from the experiment indicate that incident and congestion information types were the most important in influencing subjects' route decisions. The findings also indicate the importance of having incident information available to drivers, and that this importance is reinforced by the availability of route guidance information. Descriptive information such as incident locations and congestion levels can provide a strong rationale for compliance with prescriptive information such as route guidance.

Research at the Institute of Transportation Studies, University of California at Davis is being performed to study the impact of Advanced Traveler Information Systems (ATIS) on travel demand. If information systems and services, which can provide accurate up-to-date information on the travel environment, are made available to drivers on board their vehicles, at home, or at high-demand locations such as office complexes or shopping centers, what will be the effect on travelers' behavior? Part of this project has focused on investigating the effect of information on route choice behavior. Our research efforts in this area have employed two state-of-the-art approaches undertaken in tandem.

The first approach used sophisticated computer-aided telephone interview (CATI) surveys of Los Angeles-area morning commuters, with a follow-up mail survey to a large subgroup of the original sample, which was customized for each survey recipient (*1,2*). The goal of this series of surveys was to investigate what routes commuters were using and identify the characteristics of these routes; to determine how much information drivers have about their routes and if they have alternative routes, to investigate what sociodemographic and route specific characteristics influence drivers to use alternative routes; and how the availability and perceived accuracy of existing information affect route choice.

The second approach was to use computer simulation as a data collection tool to investigate drivers' information use and learning with an ATIS. The computer is used to simulate a hypothetical traffic network that creates the decision framework into which subjects are placed. In the first year of this research project, an experiment to collect sequential route choice data under the influence of ATIS was performed using a personal computer (PC)-based simulation (*3–6*). The experiment collected information on drivers' pretrip route choice behavior at three levels of information accuracy, 60 percent, 75 percent, and 90 percent, utilizing a simple binary choice framework in which subjects could choose either a freeway route or an alternative side street. The experimental factors that were controlled in this first experiment included the accuracy level, stops on the side road route, presentation of a justification or rationale for the advised route, feedback of actual and alternative travel times, and identification of route as a freeway. The main findings of this first experiment were that drivers can rapidly identify the accuracy level of information being provided and that they adjust their behavior accordingly. There is also evidence that indicates an accuracy threshold level does exist below which drivers will not follow advice and above which drivers readily follow advice. It was found that female subjects agreed with advice more often than males, that less experienced drivers agreed more often than experienced drivers, and that a "freeway bias" exists with drivers because they were much more willing to follow advice to take a freeway route. The model of route choice behavior had a prediction rate that was 79 percent accurate and also indicated that strong memory effects existed in the updating of the perception of information accuracy. This finding indicates that subjects placed more emphasis on the accumulation of past experiences as opposed to just the latest experiences. Analysis of the experimental treatments revealed that subjects' compliance with advice increased with increasing system accuracy, by providing subjects with feedback and a decision rationale, but that intersection stops on the side street route significantly reduced advice compliance.

As an extension of this previous simulation work, a new PC-based travel simulator has been designed and a new set of experiments were designed and carried out (*7*). Some limitations of our previous experiments included the simplicity of the choice set in the binary framework, the limit to a pretrip information context imposed by this framework, and a limited investigation of sociodemographic and travel characteristics imposed by the use of university students as test subjects. This new set of experiments was

Institute of Transportation Studies, University of California at Davis, Davis, Calif. 95616.

developed to expand the simulation and experimental design complexity to account for these previous limitations.

The main goals in the development of the simulator were to expand the traffic network to improve the realism of the choice set and to allow for investigation of route-, link-, and node-specific characteristics on subjects' decision processes. The main goals of the experimental design were to test hypotheses about the main and interaction effects of four information treatments and three demographic factors, which included incident information, route guidance information, pretrip information, congestion level information, gender, age, and education. To investigate the influence of sociodemographic and travel characteristics, regular commuters and carpoolers were recruited as test subjects.

This article summarizes the initial findings of the data collected during this set of experiments. The network and travel simulator and the experimental design are briefly reviewed. Basic statistical comparisons and an analysis of frequency tables were utilized to investigate the sociodemographic, travel, and information use characteristics of the sample. Analysis of variance (ANOVA) techniques, ordinary least squares (OLS), and generalized least squares (GLS) regression techniques are used to analyze the effects of the experimental treatments on subjects' perceptions of accuracy, on their travel decisions, and on measures of consumer demand and system valuation. The significant findings of this analysis and comparisons to previous findings are summarized in the Conclusions.

DESCRIPTION OF EXPERIMENT

Overview

The driving simulation was conducted on a DOS-based PC that simulated a driving environment and provided different types of traffic information to the subjects. Subjects were randomly recruited from the Sacramento, Calif. area by an independent recruiting firm. One-hundred people were recruited according to a specific criteria that categorized them by commuter type [single occupancy vehicle (SOV)/carpool], gender, age, education level, and driving experience. The experiment consisted of a brief preexperiment survey followed by the use of the driving simulator. All subjects who completed the experiment were paid an incentive of $50.00 in cash.

Participants using the simulator were asked to "drive" from a specific starting point to a specific destination point on the computer screen. There were a series of paths to choose between representing roadways and a freeway. Figure 1 is a sketch of the simulation screen. To help them navigate through the network, the simulator offered four types of traveler information:

- Incident information,
- En route guidance,
- Pretrip guidance, and
- Congestion information.

All participants were preassigned a treatment for their 20-day simulation. Treatments consist of some combination of the four types of information, all types of information, or no information, depending on the experimental design cell to which the subject belonged.

Network and Travel Simulator

The simulation is an interactive PC program. The screen display is composed of three main windows: a network window, an information window, and an instruction window (see Figure 1 for typical screen display). The network window displays a hypothetical traf-

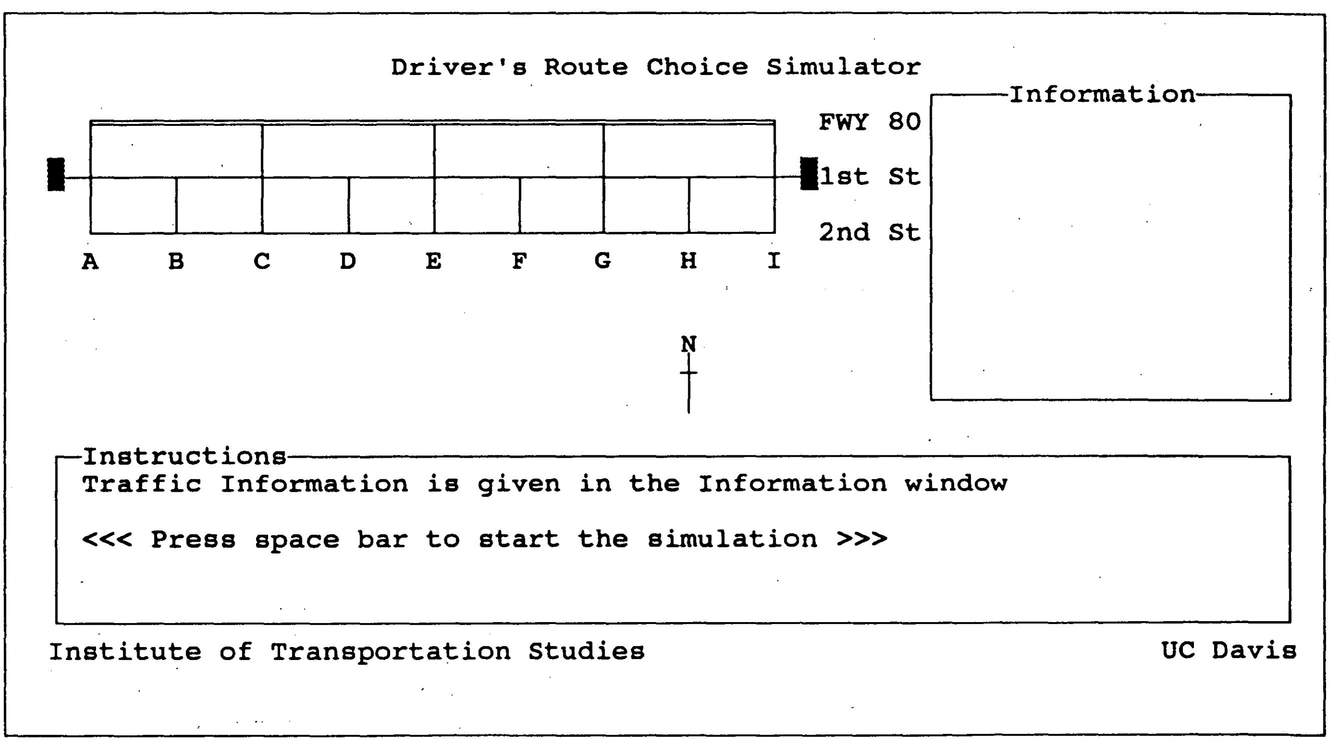

FIGURE 1 Screen display of simulator.

fic network, composed of three primary routes from an origin to a destination. The primary routes are composed of a freeway route and two arterial routes. These primary routes are cross-connected with a series of surface streets creating a network of 34 roadway links and 23 intersections (or potential decision points). The travel environment is generated by a stochastic assignment of travel speeds and stop delays to the network links and nodes. A random incident generator is used to assign an incident of random severity to the network for each travel day. The information and instruction windows are used to simulate an in-vehicle information system. Participants use keyboard arrow keys to represent driver route choices in the network for a sequence of 20 travel days (trials).

The use of the normal distribution is suggested (*8*) to represent speed distributions on roadway links. For this simulation, the network characteristic subroutine created normally distributed link speeds for each link in the network. These link speed assignments were established independent of each other in the current configuration of the simulation program. The program created a scenario in which the three primary routes through the network had similar mean speeds over the sequence of trials, but the variance in travel speed was greater on the freeway than on the arterials, and the surface streets had lower mean speeds but experienced little variation.

The simulation also contained an incident generator that stochastically assigned a traffic incident with a random severity level to one roadway link on each trial day. Links with incidents assigned had their link speed assignments automatically reduced to represent the effects of the incident. The structure of the program also allowed for assignment of incidents to intersection nodes, which would then affect speed assignments on multiple links. This option was not utilized in this series of experiments and all incidents and their effects were confined to a specific link. For a full description of the design and workings of the network and travel simulator see Vaughn et al. (*7*).

Experimental Design

The experimental design selected for this simulation study is a one-fourth fraction of a 2^7 factorial design (*9*). With two levels for each factor, a full factorial design would require a minimum of $2^7 = 128$ runs. A one-fourth fraction of this design can be used requiring a minimum of only 32 runs, and if three-way and higher interactions are assumed to be negligible, then all of the main effects are estimable and 15 of the 21 two-way interactions are also estimable. With three subjects per design block, 96 subjects are required.

Information Treatments

The simulation applied four information treatments and used three blocking factors to make up the seven experimental treatments. The information treatments are labeled A through D and the blocking factors are E through G. All treatments have two levels and are described as:

A. Incident with Description (on/off). A red icon is displayed at the location of a severe incident and a yellow icon is displayed at the location of a moderate incident. In the information window, text is used to describe the location and classification of the incident, for example, "Severe injury accident on First Street between F Street and G Street." The incident information is displayed both pretrip and en route. When the subject begins a trial day, the incident location is initially displayed and remains displayed during the trial.

B. En Route Guidance (on/off). Graphical arrows indicate advised turning movements and text description of advice. At every node, the information system provides turning movement recommendations for the next node in the form of a blinking arrow for a left turn, a right turn, or continuing straight ahead. Also, text information is provided such as "go north on B Street." The turning movement advice is based on the computed minimum path from the current cursor position to the destination. As subjects make decisions and move through the network, the minimum path is recomputed.

C. Pretrip Guidance (on/off). The minimum path is displayed at beginning of the trip. At the start of the trial, the initial calculated minimum path from the origin to the destination is outlined on the network, remains until the subjects make their first decision, and then is turned off as they are under way.

D. Congestion Information (on/off). There are color-coded links for moderate and severely congested links, with green indicating normal congestion, yellow indicating moderate congestion, and red indicating severe congestion. Like incident information, congestion information is displayed both pretrip and en route.

Three blocking factors are:

E. Gender (male/female). If subjects are male, they are in the high level of the gender factor; female subjects are in the low level of the factor.

F. Age (young/old). If subjects are in the young age group (40 years old or less), then they are in the high level of the age factor, whereas subjects in the older age group (greater than 40) are in the low level of the factor.

G. Education (high/low). If subjects are in the high education group (some college or more), they are in the high level of the education factor, whereas subjects with low education (high school graduate or less) are in the low level of the factor.

These three factors are subject characteristics that were used for recruitment and to measure individual effects on driver performance. This experimental design provides estimates of the following effects:

Main effects: A,B,C,D,E,F,G

Two-way interactions: AB,AC,AD,AE,AF,AG,BC,BD,BE,BF, BG,CD,DE,DF,DG

Aliased two-way interactions: CE = FG, CF = EG, CG = EF

SAMPLE COMPARISONS WITH STATE AND LOS ANGELES-AREA SURVEY

Table 1 summarizes and compares several demographic, travel, and information use characteristics of the simulation subjects with the California statewide travel survey (1991), as well as our previous survey of route choice from the Los Angeles area (*1,2*). The Los Angeles-area survey was a CATI survey of commuters' route choice and current information use. The statewide travel survey was a traditional trip diary survey. The characteristics that were found to be significantly different from the state survey were home ownership, commute time, and travel method. The travel method to work was a characteristic that was controlled in the sampling to ensure a significant number of carpoolers; therefore this significant difference from the state mean was to be expected.

TABLE 1 Sample Comparisons

Variable	Simulation (Sacramento)	Survey (Los Angeles)	State Survey
Demographic and travel characteristic comparisons			
Gender(male)	50.5%	51.3%	46.9% (t=.71)
Homeowner	65.3%	59.0%	76.0% (t=2.22)
Household size	2.95	3.35	3.214 (t=1.78)
Income	$42,095	$38,750	$42,021 (t=.04)
SOV commuter	74%	78.8%	91% (t=3.70)
Commute time(min)	28.4	31.9	21.77 (t=4.28)
Commute Distance(mi)	13.8	12.8	-
Comparisons of Information Use			
Listen to pre-trip	43.4%	36.5%	-
Listen to en-route	70.0%	51.3%	-
Listen to both	38.4%	27.6%	-
Rated information extremely accurate or very accurate	40.0%	50.0%	-
Change departure time due to pre-trip information	37.2%	41.1%	-
Change route due to pre-trip information	69.8%	44.2%	-
Change route due to En-route information	60.0%	43.1%	-

The significantly higher average commuting time may also be linked to some self-selection bias, because subjects who commuted shorter distances were less likely to volunteer for the simulation because it required driving a considerable distance to the University of California Davis campus. The state survey data does not have trip distance information for comparison, but it is reasonable to assume that the sample also has inflated travel distances based on the inflated travel time. A comparison between the Sacramento simulation subjects and the Los Angeles survey indicates that although the average travel time was less for the Sacramento subjects, the average commute distance was greater in Sacramento, indicating the significant differences in traffic congestion that exist. Similar findings included that people tended to listen to traffic reports while en route more than before leaving home, and route modification in response to information seemed to dominate over departure time shifts. Both the receipt and use of information tended to be higher in the Sacramento sample. Accuracy perceptions of the information drivers received were found to be very similar between the two studies with 40 percent of Sacramento subjects rating information as either extremely accurate or very accurate, and 50 percent of those in Los Angeles giving a similar ranking. As previously mentioned, females listened to pretrip traffic reports at a higher rate than males, and this was a common finding between the two samples. Another comparable result between the two samples was that of work schedule flexibility.

There were also some common findings between the two studies on the effect of individual characteristics on information acquisition and use. The trend that higher income individuals were less likely to listen to pretrip reports was common between the two studies but not significantly so in the Los Angeles survey. Significant findings that were common in both studies included: females were more likely to listen to pretrip traffic reports, longer distance commuters were more likely to listen to en route traffic reports and also more likely to change routes because of pretrip traffic reports, and subjects with higher education levels and higher incomes were less likely to change departure time because of pretrip traffic reports.

ANALYSIS OF INFORMATION TREATMENTS

At the completion of the simulation experiment, subjects were asked five questions related to their experiences with the simulation. These questions rated subjects' perceptions of the accuracy of the information received in the simulation, the importance of the information in subjects' route selection, subjects' willingness to purchase an information system, and the potential price they might be willing to pay for such a system. The questions have been labeled EQ1 to EQ5 for reference in the analysis. The responses to these questions were treated as the dependent variables for the analysis performed in this section. The wording of these questions was as follows.

EQ1. How accurate was the information you received during this simulation?

EQ2. In general, how important was the information you received in determining which route you followed during the simulation?

EQ3. If a traffic information system similar to what you experienced in this simulation were available on the market today, how likely would you be to purchase such a system?

EQ4. If you were to buy such a system, how much would you be willing to pay?

EQ5. If such a system were only available as a monthly service, how much would you be willing to pay to subscribe to such a service?

In order to investigate the effects of the experimental treatments on the subjects responses, ANOVA models were used. When a background variable (covariate) was strongly related to the dependent variable, an analysis of covariance could increase the precision of comparisons between treatments by reducing the within-group variability in the dependent variable because of the influence of the covariate. The objective then was to test appropriate hypotheses about the treatment effects and to estimate these effects. For hypothesis testing, the model errors were assumed to be normally and independently distributed with zero mean and constant variance σ^2 (*9*). Additional assumptions of the covariate model were that within each group, the dependent variable had a linear relationship with the covariate, and that the slope of the regression for each covariate was the same in each group. The strength of the ANOVA model, and the main reason it was applied in this study, was that it did not require making assumptions about the nature of the statistical relation (except for the covariates), nor did it require that the independent variables be quantitative (*10*). Full models that contained all 25 effects were estimated for each of the five dependent variables (*11*). Reduced form models were obtained by excluding all effects that were not considered at least marginally significant (i.e., at the 90 percent level) and are presented in this paper.

The constant vectors of the ANOVA factor effects model give an indication of the effects of the within-factor levels of the grouping variables on the dependent variable. These factor level constants could be estimated using a regression approach that is equivalent to the ANOVA model (*12*). An underlying assumption of the ANOVA and regression models discussed in this section is that of homoskedasticity, or constant variance of the error term. OLS residuals could be tested for heteroskedasticity by regressing the squared OLS residuals against the OLS predicted values and a constant (*12*). The test statistic was a measure of the fit of the residual regression and was the coefficient of determination (r^2) times the sample size. This test statistic could be compared with the chi-square distribution with 1 degree of freedom to test the null hypothesis of homoskedasticity. An econometric estimation package (*13*) was utilized to carry out tests of heteroskedasticity, with the results presented in Table 2. The tests indicate that three of the five regression models had significant violations of the homoskedastic disturbance assumption and therefore had inefficient estimates. To account for this heteroskedasticity, a heteroskedastic model (HET), which is a special case of the GLS regression model, could be estimated by the method of maximum likelihood using an econometrics computer package (*13*).

Accuracy Perceptions

The accuracy of the information was controlled at the 75 percent level for this experiment. This means that five of the 20 trial days were randomly assigned to have incorrect information displayed for that day. Out of every four trial days, one day was randomly selected to receive incorrect information to obtain a balanced level of accuracy and not have the inaccurate days be grouped in time, which is a possibility with a pure random assignment. On days with inaccurate information, all information was incorrect except for incident location information. The locations of incidents were always correctly displayed. This means that on an inaccurate day, the minimum path displayed was incorrect, the color-coded congestion level was incorrect, and the route guidance provided did not follow the minimum path for that day.

In general, subjects perceived the information to be considerably accurate, with 17 subjects rating the information extremely accurate and 57 subjects rating it as frequently accurate. Still, a considerable number of subjects, 22, rated the information as only moderately accurate and 3 subjects rated the information as frequently inaccurate. This indicated that significant between-subject differences in accuracy perception levels existed.

In the ANOVA model of subjects' perceptions of accuracy, the interaction effects of en route guidance and congestion information were found to be significant (F = 6.83). For factors that had significant interaction effects, the significance of the main effects were confounded by the interaction effects, and therefore, the significance of the main effects for en route guidance and congestion information could not be determined independent of the interactions. This meant that even though the F statistics indicated that en route guidance and congestion information were not individually significant, these factors were still contributing to the model via interactions with each other. The main effects of education level and incident information were found to be marginally significant (F = 3.66 and 3.24, respectively).

The ANOVA regression model for the accuracy rating of information is presented in Table 3. The results of this regression model suggested that subjects with higher education levels perceived the information to be more accurate than did less educated subjects (note this was a five-point scale with one equal to the highest rating; thus the effect of the negative coefficient was to increase the rating).

TABLE 2 Tests for Heteroskedastic Disturbances

	Test Statistic[1]				
Test Form	EQ1	EQ2	EQ3	EQ4	EQ5
$\hat{\epsilon}^2$ on $\hat{Y}$	.000	34.85	.759	7.86	12.18
$\hat{\epsilon}^2$ on $\hat{Y}^2$	.007	35.65	.532	8.47	12.53
$\hat{\epsilon}^2$ on $\log(\hat{Y}^2)$	.004	31.02	.995	7.13	11.26

[1]Chi-square critical value = 3.84 (1 df, α=0.05)

TABLE 3 HET and OLS Regression Models

Variable	Coefficient(t-statistic)				
	EQ1[a,f]	EQ2[b,g]	EQ3[c,f]	EQ4[d,g]	EQ5[e,g]
Intercept	2.113	1.644	2.299	1.946	2.228
Incident	-0.116(-1.96)	-0.357(-6.00)			0.116(1.69)
En-route	0.018(0.02)	-0.135(-2.72)	0.120(1.16)		-0.051(-0.73)
Pre-trip		-0.062(-1.07)	0.050(0.49)	-0.152(-1.90)	-0.097(-1.43)
Congestion	0.030(0.44)	-0.299(-5.12)	0.155(1.49)	-0.125(-1.56)	
Age		-0.044(-0.86)			0.024(0.37)
Education	-0.130(-1.90)				
Gender			0.060(0.59)	0.282(3.55)	
Incident*pre-trip		0.133(2.29)			
Incident*congestion		0.247(4.23)			
Incident*age		-0.183(-3.61)			0.141(2.15)
En-route*age		-0.278(-4.72)			
Pre-trip*congestion		0.240(4.01)		0.275(3.41)	
En-route*pre-trip			-0.278(-2.69)		0.285(4.18)
Incident*en-route					0.203(3.08)
En-route*congestion	-0.191(-2.79)				
Pre-trip*gender			-0.158(-1.52)		
Income			0.025(0.42)	-0.018(-0.42)	-0.084(-2.20)
Variance equation					
Alpha		0.375(12.43)		0.542(11.17)	0.422(12.08)
R^2	0.135		0.135		
Log Likelihood		-85.18		-139.33	-115.12

[a]EQ1 = dependent variable: accuracy rating of information
[b]EQ2 = dependent variable: importance rating of information
[c]EQ3 = dependent variable: likelihood to purchase a system
[d]EQ4 = dependent variable: information system valuation
[e]EQ5 = dependent variable: information monthly service valuation
[f]OLS model
[g]HET model

Also, incident information tended to increase the subjects' perception of accuracy. En route guidance and congestion information had significant interactions and had to be analyzed jointly. The net effect of having either en route guidance or congestion information or having both resulted in a decreased perception of system accuracy.

Importance of Information on Travel Decisions

Subjects also found the information to be considerably important in making their route choice decisions with 84.5 percent of the subjects indicating that the information was either very important or of some importance. The reduced ANOVA model of the importance rating of information indicated that all of the main effects in the model were paired in a significant interaction effect. The main effects of incident information and congestion information were found to be individually significant. Incident information significantly interacted with pretrip information, congestion information, and age level. Pretrip information also significantly interacted with congestion information, and en route guidance significantly interacted with age level.

The HET regression model for the importance rating of information is presented in Table 3. Because all main effects were involved in interactions, the effects of a treatment must be considered as a net effect of main and interaction effects. As an example of the effects of the treatments on the importance of the information on subjects' decisions, consider an individual in the young age group (less than 40) who had incident and congestion information versus an individual in the same age group who had en route guidance and pretrip information. The regression model indicated that for the individual with incident and congestion information, the mean rating of importance was increased by 9 percent, whereas for the individual with en route guidance and pretrip information, the mean importance rating was lowered by 5.5 percent. The combination of incident, congestion, and en route guidance produced the greatest effect with a 24 percent increase in mean rating. If all information treatments were available, the mean importance rating was increased by only 12 percent. The age level effects indicated that younger subjects found the information to be of more importance in making their route decisions.

The model indicated that the pretrip information treatment had the least effect on increasing the mean importance of information, and that having en route information in conjunction with incident and congestion information significantly increased the importance of the information. These results indicate the importance of having incident information available to drivers and that its importance was reinforced by the availability of route guidance information. Descriptive information such as incident locations and congestion levels can provide a strong rationale for compliance with prescriptive information such as route guidance.

Consumer Demand and System Valuation

The potential demand for such systems, gauged by subjects' willingness to purchase a system, seems to be fairly high, with 51.5 percent of the subjects indicating that they would be likely or very likely to purchase an information system. Thirty-nine percent indicated that they were undecided, and the remainder were either unlikely or very unlikely to purchase.

The value of traffic information services was measured by the dollar value subjects indicated they would be willing to pay for an information system of the type experienced in the simulation. The value of both a fixed-price system and a monthly service type of system were measured. Forty-eight subjects indicated that they were only willing to pay less than $200 for a system, whereas 32 subjects were willing to pay between $200 to $400, and 11 subjects were willing to pay $400 to $600. Eight subjects were willing to pay in excess of $600. The average system value was calculated as $271 based on the assumption that the responses in each group were uniformly distributed within the group. The willingness to pay for an information system as a monthly service had a similar value distribution to that of the fixed price. Forty-one subjects indicated that they were only willing to pay less than $10/month, whereas 37 subjects were willing to pay between $10 and $20/month, and 14 subjects were willing to pay $20 to $30/month. None of the subjects were willing to pay more than $75/month for this type of service. The average monthly service value was calculated as $14.25/month.

The ANOVA regression models for the system demand and valuation variables are presented in Table 3. Income was included as a covariate in all of these models based on consumer theory, even though it was not found to be significant in all models. Inclusion of income did have significant effects on other variables in the model, and this is also an indicator that the variable should be retained in the model.

In the model of system demand, the interaction effects of en route and pretrip information, as well as pretrip information and gender, were found to affect the likelihood of purchasing a system. Congestion information was found to be marginally significant individually and was retained in the model. The regression model is presented in Table 3 and indicated that subjects were more willing to purchase a system that had a combination of pretrip and en route information. Also, a system with only congestion information was more likely to be purchased over a system with either en route or pretrip information individually. For systems that included pretrip information, males were more likely to purchase than females, and for systems without pretrip information, females were more likely to purchase. The income coefficient indicated that those with higher incomes were less likely to purchase a system.

The HET regression model of system valuation is shown in Table 3. The model indicated that the interaction effects of pretrip and congestion information significantly affected the dollar value of the system to the subjects. The gender of the subjects was also shown to be individually significant. This model indicated that subjects placed a higher value on a system with both pretrip and congestion information over systems with either pretrip or congestion information individually. The coefficient on the gender variable indicated that male subjects placed a higher value on the system than did female subjects. Again, the income variable was not significant but indicated that subjects with higher incomes valued the system less.

The HET regression model for service valuation is presented in Table 3. The model indicated that the interaction effects of incident information with both en route guidance and age level, as well as the interaction effects of en route guidance and pretrip information, significantly affected the dollar value of a monthly service to the subjects. Incident information and income were found to be individually significant with incident information increasing the service value, and income decreasing the value. This model indicated that subjects put more value on a service that provided incident information, en route guidance, and pretrip information collectively, than for a system with any other combination of one or two of these treatment types. This finding suggests a certain synergism among the information treatments in which individually, the effects are not significant on modifying behavior, but collectively, the information becomes effective. The model also indicated that younger subjects placed a higher value on the service than older subjects. This is not surprising given that younger subjects were also found to rate the information as more important in their route selection.

CONCLUSIONS

Preexperiment Survey Findings

This article summarizes the initial findings of a simulation experiment carried out at the University of California at Davis to investigate information use and learning with advance traveler information. The simulation experiment was found to be an extremely useful tool in collecting sequential route choice data in the presence of information. The only other data of this type available for analysis comes from other simulation research (*14–18*). To obtain this level of data, a substantial increase in per-subject cost is required. The per-subject costs for this analysis were approximately $100 per completed subject for the 100 subjects. This can be compared with the approximate $20 per-subject required to complete the more traditional CATI survey (*1*). If one considers the trial day in the simulation as the observational unit in lieu of the subject, then this type of data collection becomes very cost effective, on the order of only a few dollars per observation.

The preexperiment survey captured many interesting aspects of commuter's information acquisition and use. It was found that 70 percent of the sample currently listen to en route traffic reports and that 43 percent listen to pretrip reports, and that almost all subjects who listen to traffic reports listen every day or nearly every day. This finding indicates that a large market exists for traffic-related information and is validated by similar findings from the Los Angeles survey. The results also indicate that this information is having an effect on commuters' travel behavior. Of those subjects who listen to pretrip information, 70 percent had changed routes at least once in the last month, and 37.2 percent had changed departure time. Of those subjects who listen to en route information, 60 percent had changed routes at least once in the last month. Although currently available information is having an effect on commuters' behavior, it is a limited effect. The majority of those who had changed routes in the last month had only changed once or twice, and of those who changed departure time, the majority had changed between one and six times. This limited effect of current information may be because of subjects' perceptions of the accuracy they receive. It was found that 60 percent of the sample rated the accuracy of current traffic information as either somewhat accurate or not very accurate. Results from the survey of Los Angeles commuters also found that the more inaccurate information was perceived to be, the less likely respondents were to have changed their routes because of either pretrip or en route information.

Acquisition of pretrip information was found to be significantly dependent on subjects' gender and income. Findings from this study, as well as those of the Los Angeles survey, indicate that females were more likely to listen to pretrip information. Subjects with higher incomes were found to be less likely to listen to pretrip information in both studies. Previous simulation experiments (*3*) involving pretrip information, found that females followed pretrip information more than males. Other researchers have also found gender differences with regard to commute aspects and traffic information use (*19,20*).

Although listening to pretrip information is significantly associated with gender and income, results indicate that the effect of this pretrip information on travel behavior is independent of gender but is dependent on commute distance (for route changing), income, education, and age (for changing departure time). Subjects with longer commute distances were much more likely to have changed their commute route because of pretrip information, whereas older, more educated, higher income subjects were less likely to change their departure time. These effects of commute distance, education, and income had similar significant effects on travel behavior for the respondents in the Los Angeles study. These findings indicate that there are significant differences between the individual characteristics that influence drivers' preferences about how they receive information and the characteristics that influence drivers' travel choices in response to receipt of such information.

Similar results are also found for the acquisition and use of en route information. Commute distance significantly affects whether an individual listens to en route information, with longer distance commuters much more likely to receive en route information. Age and the work schedule flexibility significantly contribute to whether an individual changes routes based on en route information. The finding that older subjects were more likely to change routes because of en route information seems counterintuitive on the surface. However the older age group in this study does not infer "aged," only age 41 or over. Subjects in this age group may be more experienced drivers and have more familiarity with the traffic network and therefore may have a greater awareness of alternatives that are available.

Simulation Experiment Findings

Based on the subjects' rankings, it appears that incident and congestion information types were the most important in influencing subjects' route decisions. These results are supported by the ANOVA, which also reveals some significant interaction effects. In general, subjects indicated that the information provided in the simulation was important in making their route selections. Individually, all of the information types had the effect of increasing the importance rating of the information, collectively, subjects with all but pretrip information rated the importance of the information the highest. The age level of subjects was also significant in determining the importance of information. This finding supports the validity of the use of a simulated environment as age is shown to be significant in affecting the behavior of subjects both in the simulation and in the real travel environment. Another supporting factor is that gender was shown to be insignificant in both environments. In the previous simulation experiments that used university students, it was postulated that age may have significant behavioral effects; the decision to include age effects in this design is validated by these results.

Subjects generally indicated that they found the information in the simulation to be very accurate even though the accuracy was controlled to 75 percent and they actually experienced one incorrect information day out of every five. The distribution of the accuracy rating of the information in the simulation tends to be higher than the distribution for information that subjects currently receive. Subjects' education significantly contributes to the perception of accuracy with more educated subjects perceiving the information as more accurate. Incident information also contributed to increasing the accuracy perception as incident information was always correct. The effects of en route guidance and congestion information tended to decrease accuracy ratings.

The analysis of consumer demand and system valuation found that subjects were more likely to purchase systems that contain combinations of information types over a single type. Another important finding is that although incident information is very important in influencing route choice decisions and the dollar value placed on a system, incident information was not found to significantly influence the decision to purchase a system. This reiterates that the factors that influence the use of information in the decision process are not necessarily the same as the factors that influence the acquisition of that information. Another example of this is in the findings on gender effects. It was found that gender significantly influenced the acquisition of pretrip information with females being more likely to receive pretrip information, but gender had no significant effect on the use of that information in changing routes or departure times. Also, in the simulation, gender was found to significantly contribute to system demand and valuation ratings, but did not contribute to the importance of the information in making route choice decisions.

Future Research

The findings presented in this article are initial findings from a rich data source that will continue to be explored. The analysis performed here can be enhanced by application of more advanced modeling techniques to further separate and identify the characteristics that influence the acquisition and use of information. Qualitative response modeling using logit and probit frameworks is a natural extension of the analysis performed here.

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