2005-20

Final Report

Route Preferences and the Value of Travel-Time Information for Motorists Driving Real-World Routes

Research

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC-2005-20		

4. Title and Subtitle	5. Report Date
Route Preferences and the Value of Travel-Time Information for Motorists Driving Real-World Routes	May 2005
	6.
7. Author(s) Kathleen A. Harder, John R. Bloomfield, David M. Levinson, and Lei Zhang	8. Performing Organization Report No.
9. Performing Organization Name and Address University of Minnesota Department of Civil Engineering with Center for Human Factors Systems Research and Design 122 Civil Engineering Building, 500 Pillsbury Dr. SE. Minneapolis, MN 55455	10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. (c) 81655 (wo) 95
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes
http://www.lrrb.org/PDF/200520.pdf

16. Abstract (Limit: 200 words)
Drivers receive value from traveler information in several ways, including the ability to save time, but perhaps more importantly, from certainty, which has other personal, social, safety, or psychological impacts.
This project aims to quantify travelers' willingness to pay for pre-trip travel-time information on alternative routes. Different from previous studies based only on stated preference surveys, the 117 participants in the current study actually drove real-world routes. Pre-trip travel-time information was provided in the field experiment to half the participants. Various data collection techniques were used including in-vehicle GPS units, pre- and post-experiment surveys, and travel diary.
Results reveals that speed and efficiency are not the only dimensions on which people make route choices. Ease of driving, pleasantness, and the presence of information are also significant factors. Results from multinomial and rank-ordered logit models indicate that many travelers receive value of up to $1 per trip for pre-trip travel-time information. The value of this information is higher for commuting, special event trips, and when there is heavy congestion. The accuracy of the travel-time information is crucial – it is only useful if it is believed to be accurate.

17. Document Analysis/Descriptors		18. Availability Statement
Value of information Advanced Traveler Information Systems (ATIS) Real-time traffic operations	Intelligent Transportation Systems (ITS) Travel behavior Route choice	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	62	

Route Preferences and the Value of Travel-Time Information for Motorists Driving Real-World Routes

Final Report

Prepared by:
Dr. Kathleen A. Harder
Dr. John R. Bloomfield
Dr. David M. Levinson
Lei Zhang

Center for Human Factors Systems Research and Design
College of Architecture and Landscape Architecture
University of Minnesota
and
Department of Civil Engineering
University of Minnesota

May 2005

Published by:
Minnesota Department of Transportation
Research Services Section, Mail Stop 330
395 John Ireland Boulevard
St. Paul, Minnesota 55155-1899

Acknowledgements

The authors would like to thank the Minnesota Department of Transportation for providing funding for the project. We would like to thank Brendan Nee, Nebiyou Tilahun, and Melissa Marver for working on data collection and Ingrid Nordby and Fun-Kit Lim on data entry. We appreciate the comments from members of the TAP which helped improve the value and readability of the report. The authors are solely responsible for any remaining errors in this final report.

Table of Contents

Chapter 1: Introduction..1
1.1 Introduction and Objectives...1
1.2 Literature Review..3

Chapter 2: Method..6
2.1 Participants..6
2.2 Test Routes...6
2.3 Experimental Design...7
2.4 Survey Instruments..9
2.5 Study Procedure...11

Chapter 3: Descriptive Results and Discussion...13
3.1 Route Preferences..13
3.1.1 Preferred Route...13
3.1.2 Perceived Experiece of Driving Routes...15
3.1.3 Route Characteristics..16
3.2 The Value of Travel-Time Information...27
3.2.1 Using Travel-Time Information...27
3.2.2 The Effect of Providing Travel-Time Information.......................................28
3.3 Summary..29

Chapter 4: Analytical Model Methodology...31
4.1 Route Choice and Traveler Information 31
4.2 Information Usage and Public Acceptance of Traveler Information Systems.........33

Chapter 5: Analytical Model Results..35
5.1 Importance of Various Route Attributes for Trips with Different Purposes............35
5.2 Value of Information by Trip Purposes,
Routes, and Level of Congestion..39
5.3 Determinants of Information Usage
and Public Acceptance of ATIS...42

Chapter 6: Conclusions...43

References..45

Appendix A: Survey Instruments...A-1

List of Figures

Figure 2.1. Selected routes for the field experiment..7

Figure 2.2. Participants' familiarity with the selected routes..9

Figure 4.1. Route perception and cognition...33

Figure 5.1. Reported and predicted route choices for different trip purposes................39

Figure 5.2. Value of traveler information by route, trip purpose, and level of congestion..41

List of Tables

Table 2.1. Numerical breakdown of participants as a function of gender, whether or not they received travel-time information, and the fourth route they drove..8

Table 2.2. Descriptive statistics of the subjects...9

Table 3.1. Average ranking by trip quality for participants whose four routes included Grand Avenue...13

Table 3.2. Average ranking by trip quality for participants whose four routes included Marshall/Selby...13

Table 3.3. Number of participants who selected each of the possible routes when asked which they would take tomorrow...14

Table 3.4. Number of participants who selected each of the possible routes when asked overall which they would choose most often...15

Table 3.5. Summary of four ANOVAs—F-values (and p-values) for perceived time, perceived distance, perceived speed, and perceived stopped time.......................16

Table 3.6. Summary of three ANOVAs—F-values (and p-values) for ratings of efficiency, ease of driving, and pleasantness of the routes for the participants who drove the Grand Avenue route...17

Table 3.7. Average ratings for efficiency, ease of driving, and pleasantness for each of the routes driven by the participants in the Grand Avenue group.....................17

Table 3.8. Summary of three ANOVAs—F-values (and p-values) for the ratings of efficiency, ease of driving, and pleasantness of the routes for the participants who drove the Marshall/Selby route...18

Table 3.9. Average ratings for efficiency, ease of driving, and pleasantness for each of the routes driven by the female participants in the Marshall/Selby group.......19

Table 3.10. Average ratings for efficiency, ease of driving, and pleasantness for each of the routes driven by the male participants in the Marshall/Selby group..........19

Table 3.11. Summary of four ANOVAs—F-values (and p-values) for the ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Grand Avenue Group...20

Table 3.12. Summary of four ANOVAs—F-values (and p-values) for the ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Marshall/Selby Group...20

Table 3.13. Average ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Grand Avenue group..21

Table 3.14. Average ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Marshall/Selby group..21

Table 3.15. Summary of five ANOVAs—F-values (and p-values) for the ratings of the routes for shopping, going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive— for the Grand Avenue group...............23

Table 3.16. Average ratings of the routes for shopping, going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive—for the Grand Avenue Group...23

Table 3.17. Summary of five ANOVAs—F-values (and p-values) for the ratings of the routes for shopping, going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive— for the Marshall/Selby group..............24

Table 3.18. Average ratings of the routes for shopping for the female and male participants in the Marshall/Selby group...24

Table 3.19. Average ratings of the routes for going to the theater or a movie, Visiting family or friends, going to a park, or a Sunday drive—for the Marshall/Selby Group..25

Table 3.20. Average rankings of the routes considered for commuting, shopping, going to a special event, taking a recreational trip, visiting family or friends, or

taking a Sunday drive—for the Grand Avenue group...26

Table 3.21. Average rankings of the routes considered for commuting, shopping, going to a special event, taking a recreational trip, visiting family or friends, or taking a Sunday drive—for the Marshall/Selby group..26

Table 3.22. Responses to question about frequency of use of travel-time information..27

Table 3.23. Average rankings of the usefulness of travel-time information for six types of trips...28

Table 3.24. Responses to question about provision of travel-time information............28

Table 5.1. Results: rank-order logit models...36

Table 5.2. Results: multinomial logit models...37

Table 5.3. Results: ordinary linear regression...38

Table 5.4. Information usage..42

Executive Summary

A major strategy of federal ITS initiatives and state departments of transportation is to provide traveler information to motorists through various means, including variable message signs, the Internet, telephone services like 511 Traveler Information Services, in-vehicle guidance systems, and TV and radio reports. Drivers receive value from traveler information in several ways, including the ability to save time, but perhaps more importantly, other personal, social, safety, or psychological impacts from certainty. The success of ATIS (Advanced Traveler Information Systems) depends on travelers' responses to the information, which are contingent on a number of properties of the transportation system, user characteristics, and the information itself: quality, accuracy, usefulness, timeliness, user customization, cost, and the manner in which information is provided. Design and implementation of cost effective ATIS call for the understanding of the value of information for motorists. This project aims to quantify travelers' willingness to pay for pre-trip travel-time information on alternative routes. Other related issues, such as users' preference for various route attributes and ATIS service providers, are also explored.

Traffic models have been developed from studies using Stated Preference methodology. The current study uses a variant of this methodology: Rather than *asking* subjects to state preferences based on alternatives that were only *described*, the 117 participants in the current study *actually drove* real-world routes and then were asked to state their preferences. They also rated various attributes of the routes after driving them, as well as ranking them, after all the routes had been driven. The actual route attributes were measured by on-vehicle GPS units. Travel-time information was provided to half the participants, who were then asked to assess its usefulness.

The results revealed two routes—I-94 and Summit Avenue—were clearly preferred to three other routes for trips taken under time pressure (i.e. commute and event trips). Participants indicated that I-94, a freeway, took less time to drive, was shorter in distance, could be driven faster, and had less stopped time than Summit Ave and three other routes. Consequently, the finding that Summit Avenue, which has a parkway or boulevard character, is preferred as much if not more than I-94, indicates that speed and efficiency are not the only dimensions on which people make route choices. Possible explanations as to why Summit Avenue and other arterial streets were sometimes favored are found in the ratings and rankings of efficiency, ease of driving, and pleasantness.

With regard to travel-time information, while 74% of participants said they would use the information, 80% said they were not willing to pay for it. 69% of participants said ATIS service should be provided free by the public sector, and 19% prefer for-profit private service charging users a fee possibly due to concerns of service quality. Multinomial and rank-ordered logit models—based on the Stated Preference and GPS data—produced estimates of the value of time information. These estimates indicated that many travelers receive value of up to $1 per trip for pre-trip travel-time information. The value of this information is higher for commuting, special event trips, and when there is heavy congestion. The accuracy of the travel-time information is crucial—it is only useful if it is believed to be accurate. Nonetheless, to support the provision of information, it would be good to have some way of transferring resources from those who want information (travelers) to those who can provide information (agencies, cell-phone operators, others) and achieve a win-win situation.

CHAPTER 1
INTRODUCTION

1.1 Introduction and Objectives

Because traffic is increasing faster than capacity can be added, the Federal and State Departments of Transportation are focusing on ways to reduce traffic levels on congested highways, to make driving less onerous, and to make trips more predictable—particularly during peak traffic hours. Advanced travelers information systems (ATIS) and advanced traffic management systems (ATMS) have been proposed and implemented in a number of metropolitan areas to help mitigate congestion. The two types of systems are often integrated because the successful operation of both requires a sensor network that collects real-time traffic data, and an online data analysis package that identifies the current and/or predicts the future states of the system. They, however, differ in how the information is used. ATIS communicates the information, such as travel time between an Origin-Destination pair on alternative routes, to individual users through various means to help them make better travel-related decisions. ATMS in general takes advantage of the information by operating traffic control devices such as traffic lights, ramp meters, and incident management. Transportation analysts rely heavily on sophisticated traffic models when they make decisions that impact traffic flow on road systems for which they are responsible.

Many traffic models have been developed from studies that utilize computer simulation, or use Stated Preference or Revealed Preference methodologies to acquire route preference data from drivers. Typically, researchers use computer simulations to attempt to predict traffic flow under various combinations of conditions and derive travel demand on routes that is an input to the model assuming travelers maximizing their own utility. However, traditionally that utility only includes travel time, and assumes that travelers know the travel time and monetary cost on all potential routes, assumptions that are at best a crude approximation. In Stated Preference studies, drivers are asked to state which alternative they *would choose* when two, or more, possible alternatives are presented to them, while in Revealed Preference studies drivers inform investigators which of two, or more, possible alternatives they *actually chose*. The data obtained with Stated and Revealed Preference methodologies are typically used to derive route-choice models that assume drivers make choices subject to constraints "such as time, money and peer pressure" (Louviere & Street, 2000, page 136).

The current study uses a variant of Stated Preference methodology. Rather than ask drivers to state their route preferences based on possible alternatives that were only *described* on paper or on a computer screen, in the current study they *actually drove* four real-world routes and then were asked to state which alternative they preferred. The drivers who participated in the study, also provided much additional information about the routes on which they drove, rating various attributes of the routes after driving each of them, as well as ranking them after all had been driven. We also provided travel-time information to half of the participants, and then asked them to assess its usefulness.

The specific objectives of the study were—

- To determine the route preferences of drivers who drove on selected real-world roads.
- To determine the usefulness of travel-time information to drivers who drove on selected real-world roads.

To meet these objectives, we selected several alternative routes between the McNamara Alumni Center at the University of Minnesota in Minneapolis and the Cathedral of St. Paul in St. Paul. The routes, which included a freeway, an arterial road, a parkway, and urban roads, have very different characteristics. However, they are roughly parallel to each other geographically and they provide reasonable alternative routes to travel between the two locations. After driving four of these routes, the subjects participating in the study were asked to state their route preferences. In addition, half the subjects were given travel-time information before they began driving each route and they were asked to assess its usefulness after they had driven them.

This research investigates the factors influencing route choice, including ATIS, to assess the value of traveler information for motorists, and to understand public acceptance of ATIS. The large body of literature that has examined similar issues is reviewed in the following section. While these studies tried to estimate the benefits of traveler information, they all did so at a theoretical level or in a simulation context, and generally attempted to measure time saved. Our research extends the previous research in two important and practical directions. First, the data for this study were collected in a comprehensive field experiment. In the experiment, a large number of travelers, with or without pre-trip information, drove both freeway and arterial routes in a large real-world network, assessed the information, evaluated the importance of information accuracy, and revealed their route preferences for various trip purposes. Second, the focus of this study was to derive the value of traveler information under different circumstances, or users' willingness to pay for information services. By the very nature of the design, we did not consider the value of information directly in terms of observed/computed time savings, but rather in perceived reduction of time cost *and* uncertainty.

Users should be willing to pay for traveler information because such services can reduce travel costs, uncertainty, and anxiety. The benefits of ATIS to users therefore are in terms of not only time and monetary savings, but also emotional and psychological well-being. There are several reasons why it is important to understand users' willingness to pay for traveler information. First of all, the true benefits of ATIS cannot be appropriately evaluated without a thorough understanding about willingness-to-pay and consumers' surplus. Second, market share is an important factor determining the impacts of ATIS on the system performance, which is the result of the direct interplay of willingness-to-pay and the cost of acquiring traveler information. Finally, knowing how much users want to pay for traveler information is necessary for the design of sustainable for-profit private or public-private partnership ATIS services.

This research will also help in understanding the route selection process with and without traveler information for different trip purposes. Regression analysis and discrete choice models are the primary methodological tools. The information gained from this study will enable transportation engineers to design future information systems in ways that reduce driver frustration. Reduced driver frustration is likely also to lead to fewer aggressive driving incidents.

The remainder of this report is organized as follows. The following sub-section reviews previous studies on ATIS and route choice. Section 2 describes data and the field driving experiment in detail, as well as pre- and post-experiment surveys. Section 3 reports on statistical relationships between the measured variables. Sections 4 and 5 provide an account of the statistical modeling efforts and other methodological issues, followed by the interpretation and discussion of results. Conclusions are offered at the end of the report.

1.2. Literature Review

Travelers rely on their spatial knowledge about the physical and built environment to make travel-related decisions, such as job and residential location, vehicle ownership, activity schedule, activity location, travel model, and routes. The decision-making process is also typically subject to a number of determinants and constraints imposed by the physical, built, economic, and societal environment, as well as the imperfection of travelers' perception and cognition capabilities (Hensher & Goodwin, 1978; Golledge & Stimson 1997). Information plays a key role in travelers' perception, cognition, and decision-making processes. Travelers learn about the environment through various information sources, including personal experience, inter-personal communication, maps, and mass media. ATIS has the potential to improve travelers' decision-making process by providing relevant real-time information about the state of the transportation system.

At the individual level, users can benefit from ATIS in terms of travel-time savings and travel certainty (Levinson, 2003). Since a number of previous studies have explored theoretical and estimation issues with regard to the value of travel time (Hensher, 1975; Bates, 1987; Jara-Díaz, 1990; Hensher, 2001; Jara-Díaz, 2000; Hensher & Goodwin, 2004) and the value of travel-time variation (Small *et al.*,1997; Small *et al.,* 1999), the two components of the value of traveler information may be estimated separately. Many researchers have attempted to estimate the travel-time savings with ATIS technologies (Kanafani & Al-Deek, 1991; Emmerink *et al.,* 1995; Wunderlich, 1995; Emmerink *et al,.* 1996; Inman & Peters, 1996; Peckmann, 1996; Wunderlich, 1996; Alder *et al.,* 1999; Levinson, 2003). Although their findings suggest ATIS could reduce travel time for equipped vehicles and overall, under non-recurrent and recurrent congestion conditions, and with various level of market penetration, several studies conclude that ATIS by itself should not be considered as a solution to the peak-period congestion problem or as an effective alternative to traditional capacity expansion (Hall, 1993; Levinson, 2003). The value of reduced travel uncertainty under ATIS, however, has not been rigorously examined and incorporated into ATIS studies. Alternatively, the two components of the value of traveler information may be estimated together by a willingness-to-pay measure. This approach has been explored in several studies based on stated-preference surveys in which travelers were directly asked how much they are willing to pay for specific ATIS services (Wolinetz *et al.,* 2001; Khattak *et al.,* 2003). Based on the authors' best knowledge, no previous studies have developed choice models to estimate willingness to pay for traveler information.

At the agency level, the decision to adopt ATIS usually involves estimation of user benefits, social benefits, and implementation cost, as well as several other important policy issues. When the majority of the drivers are risk-averse in that they may travel more with improved travel-time reliability but slightly increased average journey time, the implementation of ATIS could in some cases hurt the uninformed drivers (Levinson, 2003). There might be a horizontal equity issue in this regard. There have also been discussions on the nature of ATIS. Hall (1996) argued that ATIS should be viewed first as a service to the public, and second as a means for steering traffic toward user optima that utilize feasible alternate routes. Al-Deek *et al.* (1998) found that traffic diversion with ATIS may reduce overall safety because more drivers use less safe arterial streets. Khattak *et al.* (2004) provide a discussion of various design and evaluation issues related to ATIS.

The provision of traveler information by ATIS can induce a number of possible short-run responses from the users. Travelers, knowing the level of congestion on alternative routes, may decide not to travel at all, change destinations, change departure times, change modes, and change routes. So far, no evidence suggests that ATIS could significantly affect long-term behavior such as job and residential locations. Most previous studies examined the impacts of ATIS on route choice and traffic equilibrium (Van Vuren *et al.,* 1989; Koutsopoulos & Lotan, 1990; Ben-Akiva *et al.,*1991; Mahmassani & Jayakrishnan, 1991; Al-Deek & Kanafani, 1993; Khattak *et al.,* 1993; Koutsopoulos & Xu, 1993; Chang & Junchaya, 1995; Emmerink *et al.,* 1995; Hall, 1996; Abdel-Aty *et al.,* 1997; Maher & Hughes, 1995; Deakin, 1997; Jha *et al.,* 1998; Yang, 1998; Wunderlich, 1998; Yang & Meng, 2001; Lo & Szeto, 2002; Wahle *et al.,* 2002; Levinson, 2003; Pattanamekar *et al.,* 2003; Srinivasan & Mahmassani, 2003; Yin & Yang, 2003; Lo & Szeto, 2004). One study explored the effects of ATIS on destination and route choices for shopping trips (Mahmassani *et al.,* 2003). This is not surprising because it is anticipated that the most significant impacts of ATIS would be on route choices. These studies differ in assumptions about users responses to information (route switching behavior, fixed and variable OD demand), traffic assignment criteria for informed and uninformed drivers (user optimal, stochastic user equilibrium, social optimal etc.), quality of the information (perfect and imperfect), types of congestion (recurring and nonrecurring), market penetration of equipped vehicles (endogenous and exogenous), and properties of the traffic models (static, dynamic, and queuing models etc.). Most studies make unverified assumption about driver behavior, while few studies discuss the importance of laboratory and field experiments (Schofer *et al.,* 1993). In general, previous findings suggest that the success of ATIS depends on users' responses, accuracy of information, customization of information, percentage of informed drivers, availability of alternative routes, level and types of congestion, and the magnitude of induced demand.

Various types of ATIS services have been proposed and explored in previous studies. Traveler information can be provided before a trip (pre-trip or origin-based) is made, or en route (Mahmassani & Chen, 1991). Different types of information can be provided ranging from accident alert, travel-time estimates on alternative routes, and route-guidance information, to more comprehensive organized information about a tour or an activity plan. Currently, most passenger ATIS services are provided through one-way communication such as radio, television, Internet, and variable massage signs (VMS). In-vehicle route guidance systems allow users to identify the desirable destination and route. More advanced location-based services allow users to specify a set of activities and time budget (Schiller & Voisard, 2004). Commercial ATIS services are provided through two-way communication enabling information exchange between vehicle operators and dispatchers (Ng *et al.,* 1995). ATIS can be provided by for-profit private companies (Lo & Szeto, 2002), or by the pubic sector, or through a public-private partnership (Gilroy *et al.,* 1998), or through a club-type organization (Levinson, 2002). A number of state departments of transportation in the U.S. provide real-time traffic information through radio, television, Internet, and 511 Traveler Information Services. Other noteworthy ATIS projects include the CALTRANS Smart Traveler in Los Angeles (Behnke, 1992); TravTek in Orlando (Perez *et al.,*1993); ADVANCE in Chicago (Ligas *et al.,* 1993); and FASTTRAC in Michigan (Barbaresso & Grubba, 1993). In Europe, STORM has been implemented in Stuttgart, Germany (Peckmann, 1996).

CHAPTER 2
METHOD

2.1 Participants

There were 117 participants in the study—61 were female and 56 were male. All are employees of the University of Minnesota. Participants were recruited from the pool of more than 15,000 staff employees at the University of Minnesota. Staff employees were recruited because of their more regular work hours and commute times. Only respondents who drive when they commute to work at the University were invited to participate in the study. In addition to excluding those who do not drive to work, other employees were excluded from participating in the study for the following reasons: (a) those 5,400 employees who live outside the Minneapolis-St. Paul metropolitan area were excluded; (b) all employees from the groups with which the authors are associated—i.e., employees from the Center for Human Factors Systems Research and Design and from the Department of Civil Engineering were excluded; and (c) all employees who participated in earlier Stated Preference studies (Levinson, Harder, Bloomfield, & Winiarczyk, 2004; and Tilahun, Levinson, & Krizek 2005) were excluded. We recruited participants by sending an email to a random sample selected from the resultant subject pool. Those who responded to the email obtained further information about the study in a phone conversation.

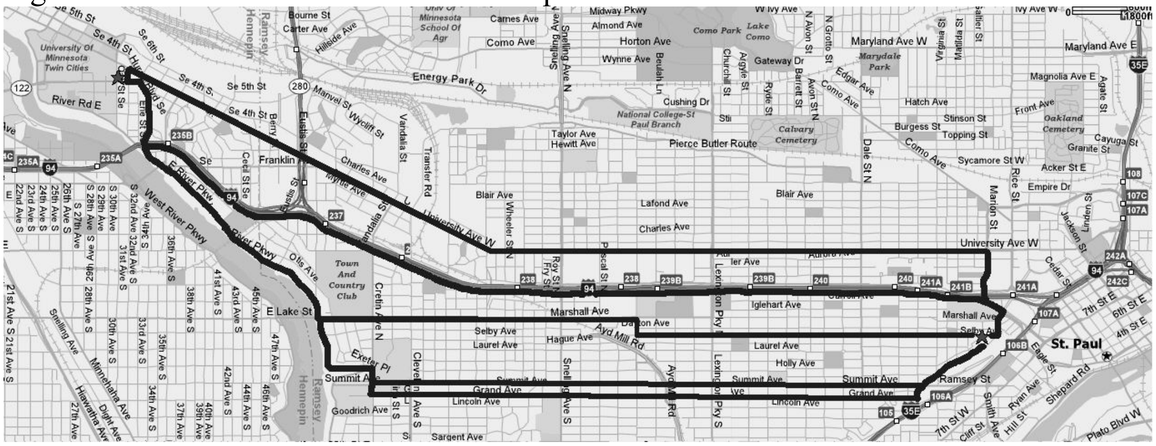
2.2. Test Routes

Five test routes were used in the study. The endpoints for all five routes were the McNamara Alumni Center located on the east side of the campus of the University of Minnesota, in Minneapolis, and the Cathedral of St. Paul in St. Paul. The five routes, which are shown in Figure 2.1, were as follows:

1. *Via University Avenue*—an arterial road that used to be the main route between Minneapolis and St. Paul. It has a number of intersections with traffic lights.
2. *Via Interstate 94 (I-94)*—a freeway with three lanes in each direction. It is now the main route between Minneapolis and St. Paul.
3. *Via Summit Avenue*—a parkway, much of which is lined with grass and trees and some of which has a wide grass-covered central island with many trees. It has a number of intersections with traffic lights.
4. *Via Grand Avenue*—a road that has mainly boutique-style shops as well as some houses. It has a number of intersections with traffic lights.
5. *Via Marshall Avenue and Selby Avenue*—two roads that have some sections with houses and some with small shops. Both roads have some intersections with traffic lights.

As mentioned above, the participants were all employees of the University of Minnesota—and thus can be expected to have some familiarity with roads and highways in the Twin Cities area.

Figure 2.1. Selected routes for the field experiment



Routes from the top: University Avenue, I-94, Marshall Avenue and Selby Avenue, Summit Avenue, and Grand Avenue.

As Figure 2.1 shows, the five routes are roughly parallel. During peak travel periods, the level of congestion on these routes—particularly on I-94—can be relatively high.

2.3 Experimental Design

Each participant drove in his or her personal vehicle on four of the five test routes. All 117 participants drove via University Avenue, I-94, and Summit Avenue. The fourth route was via Grand Avenue for 60 participants, and via Marshal and Selby Avenue for the remaining 57 participants.

The experiment was conducted on Mondays, Tuesdays, Wednesdays, and Thursdays. On these days, the participants drove in one of three approximately two-hour time slots—between (1) approximately 7:00 a.m. and approximately 9:00 a.m.; (2) approximately 11:00 a.m. and approximately 1:00 p.m.; or (3) approximately 4:00 p.m. and approximately 6:00 p.m. The start times for the participants were staggered, with approximately five minutes between each start and all four drives for each participant occurred within the same two-hour time frame. So, for example, if a participant began driving at 7:00 am, he or she would finish the fourth drive at approximately 9:00 am, while a participant who began driving at 7:05 am would finish the fourth drive at approximately 9:05 am.

On the first and third drives, each participant drove from the University of Minnesota in Minneapolis to the Cathedral of St. Paul in St. Paul, while on the second and fourth drives, he or she drove back from the Cathedral to the University. The order in which they drove the four routes was counterbalanced across subjects.

Fifty-five participants were given travel-time information at the start of each drive. Sixty-two participants did not receive travel-time information. The participants who were given travel-time information were told that it was "current" travel-time information. They were given this information immediately before each of their four drives. It was given to them by a Research Assistant (RA) who first looked into a "Travel-time Estimator" (TTE). It should be noted that the TTEs were actually GPS instruments. In fact, they could not provide real-time travel-time information based on the current traffic conditions—instead the travel-time information given to the participants was based on travel times obtained by driving each of the routes several times during the testing times (i.e., between 7:00 a.m. and 9:00 a.m., between 11:00 a.m. and 1:00 p.m., and between 4:00 p.m. and 6:00 p.m.) prior to the onset of the study. The travel times were estimates for each of the particular routes during the time period that the participant was driving, and consequently could have been inaccurate at times.

The breakdown of participants as a function of gender, whether or not they received travel-time information, and whether their fourth route was via Grand Avenue or via Marshall/Selby is presented in Table 2.1

Table 2.1: Numerical breakdown of participants as function of gender, whether or not they received travel-time information, and the fourth route they drove

Fourth Route	**Female [*With* Travel-time Information]**	**Male [*With* Travel-time Information]**	**Female [*Without* Travel-time Information]**	**Male [*Without* Travel-time Information]**	**Total**
Via Grand Avenue	13	12	20	15	60
Via Marshall/Selby	14	16	14	13	57
Total	27	28	34	28	117

A summary of the socio-demographic features of the final sample is provided in Table 2.2. There is sufficient variation in age, gender, education, income, household structure, and travel patterns among the selected subjects. The sample is representative of the general driving population, except that the level of education of the subjects is a bit higher than the regional average.

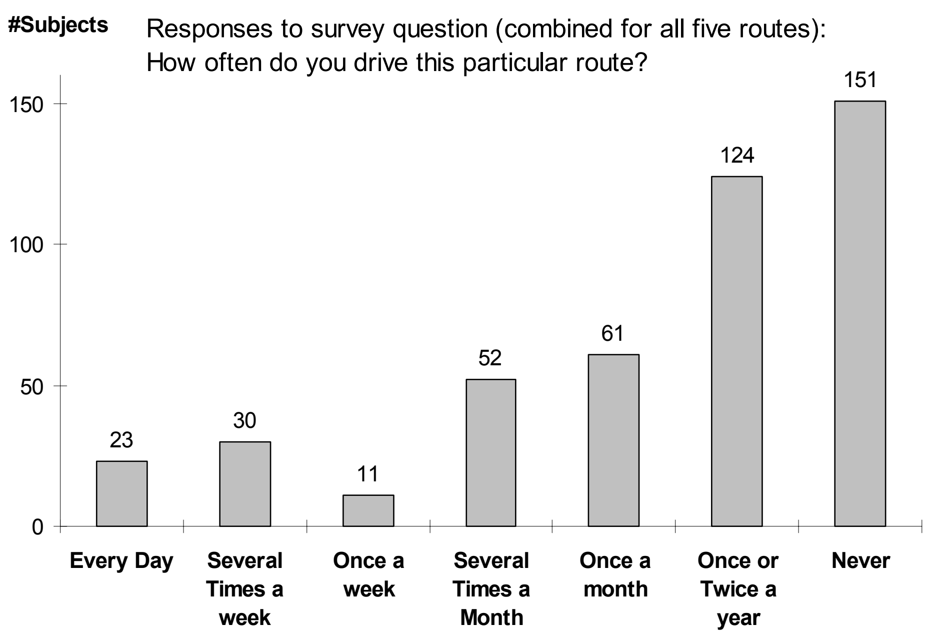
Drivers' familiarity with routes very likely affects their route choice behavior. It is therefore important to ensure that participants are neither uniformly very familiar nor very unfamiliar with the selected five routes and the geographic area. Otherwise, the route choices they make may not be representative, as well as the underlying decision-making process. All participants were queried as to how often they normally drive on the selected routes. Their responses are summarized in Figure 2.2. Although there does not exist verification data at the population level (i.e. all drivers in the Twin Cities), the variation of route familiarity among the survey participants confirms that the undesirable extreme cases are avoided.

Table 2.2. Descriptive statistics of the subjects*

Variables	**Counts**
Females / Males	58 / 55
HH income (< $50K / < $100k / > $100k)	36 / 58 / 19
Age (<35 / <55 / >55)	37 / 58 / 18
Education: (< 2-y college / < 4-y college / post-graduate)	27 / 41 / 45
HH size (1 / 2 / 3 / >=4)	23 / 48 / 20 / 22
HH Num. Autos (1 / 2 / 3 / >=4)	28 / 65 / 12 / 8
Commute time (min) (10 / 20 / 30 / 40 / >40)	3 / 29 / 42 / 23 / 16
Commute distance (mile) (5 / 10 / 15 / 20 / >20)	14 / 39 / 29 / 14 / 17
Number of trips/day (2 / 5 / 10 / >10)	13 / 37 / 55 / 8
Years at city (5 / 10 / 20/ 30 / >30)	16 / 16 / 23 / 16 / 42

*Please note complete socio-economic data were only available from 113 of the 117 participants in the study.

Figure 2.2. Participants' familiarity with the selected routes



2.4 Survey Instruments

Two survey instruments were used in the study. The first instrument, which was used to obtain *ratings* of various aspects of the routes, was presented four times — immediately after the participant finished driving each of the four routes. The second instrument, which was used to obtain *rankings* of the participant's preferences for particular aspects of each route, was presented once — after the participant had driven all four routes.

2.4.1 Rating Instrument

The *rating* instrument asked each participant to *rate* the overall quality of various aspects of the route. All the ratings were made on a 7-point category scale—where "1" was the poorest rating, and "7" was the best rating. There were two versions of the survey instrument—one for participants who were given travel-time information, the other for those who were not. Both versions are presented in Appendix A.

The first three questions in the *rating* instrument asked the participant to "think of the route that you just drove as part of your commute to or from work" and rate it with regard to—(1) "its efficiency"; (2) "how easy it was to drive"; and (3) "how pleasant it seemed to be." Then, if the participant received travel-time information, he or she was asked to rate the accuracy and the usefulness of the information. However, if the participant did *not* receive travel-time information, these two questions were omitted. Next, participants were asked how often they drove the particular route, and whether or not they were listening to traffic reports on the radio while they were driving on it. Then, they were asked to think of the route "as part of your commute to or from work", and asked how he or she "would rate driving a route very much like" it—(1) to work, "assuming *no stops* for shopping, daycare, and the like"; (2) to work, assuming that he or she would "make *typical stops* for shopping, daycare, and the like"; (3) home from work, "assuming *no stops* for shopping, daycare, and the like"; and (4) home from work assuming that he or she would "make *typical stops* for shopping, daycare, and the like." In the final questions on the *rating* instrument, the participants were asked how they "would rate driving a route like this for"—(1) shopping; (2) going to the theater or a movie; (3) visiting family or friends; (4) going to a park; and (5) a Sunday drive—before being asked whether anything unusual occurred when driving the route.

Again, the participants used the rating scale in such a way that, if they rated a particular aspect of the route (e.g., ease of driving) very highly, it was given a rating of "7" (meaning, for example, that it was very easy to drive), while if they rated the aspect as very poor it was given a rating of "1" (meaning, for example, that it was very difficult to drive).

2.4.2 Ranking Instrument

The *ranking* instrument asked the participant to compare the four routes that he or she had driven, to chose between them, *ranking* them in order of preference in terms of various aspects of the route, with the most preferred route being number "1" and the least preferred route being ranked number "4." Again there were two versions of the survey instrument—one for participants who received travel-time information, the other for those who did not—and both versions are presented in Appendix A

The first question in the *ranking* instrument asked the participant to "rank the four drives in terms of their drive quality." Then, the participants were asked, if they had to drive between the University and the Cathedral *tomorrow*, which route they would take. In the next four questions, the participant was asked for all four routes—(1) how many minutes the trip took; (2) how many miles he or she had to drive; (3) the average speed; and (4) the number of minutes he or she had to stop (because of traffic lights, ramp meters, or traffic congestion). Then, the participants were asked which method of obtaining directions (map, written, or both) they preferred. Next a series of questions followed in which the participant was asked to rank the four routes in terms of using them for—(1) commuting; (2) shopping; (3) going to a special event; (4) taking a recreational trip; (5) visiting family or friends; and (6) going on a Sunday drive. After this came a key question—it was "Overall, which route would you choose most often." There were five final questions on this instrument, for participants who received travel-time information. First, they were asked whether or not they would use travel-time information, like that provided in the study, to make a choice between routes. Second, if the answer to the first question was yes, how often they would use the information. Third, how they would rank its usefulness for—(1) commuting; (2) shopping; (3) going to a special event; (4) taking a recreational trip; (5) visiting family or friends; and (6) going on a Sunday drive. Fourth they were asked how much they would be willing to pay for this information. And fifth, they were asked whether this information should be provided "free by the public sector, at a charge by the private sector, or not provided at all." For those participants who did *not* receive travel-time information, these final five questions were omitted.

Again, when the participants gave rankings, the route which they ranked number "1" was the route that they judged to be the best in terms of a particular aspect (e.g., they judged it to be best of the four routes for commuting), while the route they ranked number "4" was the worst (e.g., they judged it to be the worst of the four routes for commuting).

2.5 Study Procedure

2.5.1. Pre-Drive Procedure

Each participant provided the following socio-economic, demographic, vehicle, and preference data—(a) age; (b) home income; (c) educational level; (d) number of family members living at home; (e) number of vehicles at home; (f) typical daily commute time; (g) typical daily commute distance; (i) typical number of trips per day; and (k) number of years lived in the Twin Cities. Next, the participant completed a standard travel diary for the day prior to the test day.

The first drive began in Minneapolis, at the McNamara Alumni Center on Oak Street (on the east side of the campus of the University of Minnesota). Immediately before the first drive, a Global Positioning System (GPS) was placed in the participant's vehicle—the GPS unit recorded vehicle location data at one-second intervals, allowing us to track the actual route taken by the participant, to determine the length and number of stops they made, and the speed at which they drove.

2.5.2 First Drive

A research assistant (RA) gave the participant instructions as to which route to drive first. If the participant received travel-time information, the RA looked into the Travel-time Estimator and told the participant the "current estimated" travel time for the first route. [This step was omitted for participants who did not receive travel-time information.] The RA also told the participant where to meet a second RA in the car park of the Cathedral of St. Paul. Then, the participant drove the first route. On arrival at the Cathedral, he or she met the second RA. The second RA gave the participant the *rating* instrument, which asked the participant to *rate* the quality of various aspects of the route.

2.5.3 Second Drive

Then, the second RA gave the participant instructions for the second route. Also, if the participant received travel-time information, the second RA looked into a TTE and then announced the "current estimated" travel time for the second route. After completing the second drive, the participant again met with the first RA at the McNamara Alumni Center on Oak Street. The first RA gave the participant another copy of the *rating* instrument and asked the participant to rate the various aspects of the route taken on the second drive.

2.5.4 Third Drive

The first RA gave the participant instructions about the third route. Again, if the participant received travel-time information, the RA looked into the TTE and told the participant the "current estimated" travel time for driving the third route. Then, the participant drove the third route. When he or she arrival at the Cathedral, the second RA gave the participant a copy of the *rating* instrument and the participant rated the various aspects of this route.

2.5.5 Fourth Drive

The second RA gave the participant instructions for the fourth route and, if the participant received travel-time information, the second RA provided the "current estimated" travel time for the second route. On completion of the fourth drive, the participant obtained another copy of the *rating* instrument from the first RA, and rated various aspects of the route taken on the fourth drive.

2.5.6 Post Drive

After completing the ratings for the fourth drive, the participant went to a Subject room in the Civil Engineering Department where he or she met with a third RA. The third RA gave the participant the *ranking* instrument with which the participant could provide comparative *rankings* of the four routes, and their various aspects. Finally, each participant was given $60 for taking part in the study.

CHAPTER 3
RESULTS AND DISCUSSION

3.1 Route Preferences

3.1.1 Preferred Route

The participants in this study provided a great deal of information about each of the four drives that they each took—both by completing the *rating* instrument after driving each route and then by completing the *ranking* instrument at the end of their session. There were three places in which they indicated their route preference—all in the *ranking* instrument. First, they were asked specifically to "rank the four drives in terms of their drive quality." Then, they were asked, if they had to drive between the University and the Cathedral *tomorrow*, which route they would take. Later in the *ranking* instrument the participants were asked, "Overall, which route would you choose most often?" The responses to these three questions are presented below.

3.1.1.1 Ranking by Trip Quality—The average rankings for the participants whose four routes included Grand Avenue are presented in Table 3.1; while the average rankings for those whose four routes included Marshall/Selby are presented in Table 3.2.

Table 3.1: Average ranking by trip quality for participants whose four routes included Grand Avenue [Please note: Participants were instructed to rank the routes from 1 - 4, with "1" reflecting the *most* favorable and "4" indicating the *least* favorable.]

Route	**Average Ranking**
Summit Ave	1.80
I-94	2.25
Grand Avenue	2.44
University Avenue	3.49

Table 3.2: Average ranking by trip quality for participants whose four routes included Marshall/Selby. [Please note: Participants were instructed to rank the routes from 1 - 4, with "1" reflecting the *most* favorable and "4" indicating the *least* favorable.]

Route	**Average Ranking**
Summit Ave	1.75
I-94	2.21
Marshall/Selby	2.79
University Avenue	3.25

A Friedman Two-Way Analysis of Variance (ANOVA) by Ranks was used to analyze the ranking data summarized in both Table 3.1 and Table 3.2. The value of the Freidman statistic was 51.58, for the Grand Avenue participants (Table 3.1), and 43.29, for the

Marshall/Selby participants (Table 3.2)—in both cases far exceeding the Critical Value of 16.27 required for significance at the $p<0.001$ for 3 *df*.

Inspection of both tables shows that, when asked to rank the routes they drove in terms of quality, the participants in both the Grand and Marshall/Selby groups ranked—

- Summit Avenue as the best;
- I-94 as the second best;
- Grand Avenue and Marshall/Selby were third best by the participants who drove them;
- and, University Avenue as the worst.

<u>3.1.1.2 Preferred Route Tomorrow</u>—The frequency distribution of the responses to the question asking the participants which route they would take, if they had to drive "between the University and the Cathedral tomorrow", is presented in Table 3.3.

Table 3.3: Number of participants who selected each of the possible routes when asked which they would take tomorrow*

Route	**Frequency**
Summit Ave	50
I-94	50
Grand or Marshall/Selby	10 (5 Grand, 5 Marshall/Selby)
University Avenue	6

*Please note that one of the 117 subjects did not respond to this question.

The χ^2 One-Sample Test was used to analyze the data reported in Table 3.3. The χ^2 value obtained was 61.10, which exceeds the Critical Value of 16.27 required for significance at the $p<0.001$ for 3*df*.

Inspection of Table 3.3 shows that the participants were equally likely to choose the Summit Avenue and I-94 routes, and far more likely to choose either Summit or I-94 than they were to select the Grand Avenue, Marshall/Selby, or University Avenue routes.

<u>3.1.1.3 Route Chosen Most Often</u>—The frequency distribution of the responses to the question asking the participants, "Overall, which route would you choose most often?" is presented in Table 3.4.

The data reported in Table 3.4 were analyzed using the χ^2 One-Sample Test. In this case, the χ^2 value obtained was 55.64—this also exceeds the Critical Value of 16.27 required for significance at the $p<0.001$, for 3 *df*.

Table 3.4: Number of participants who selected each of the possible routes when asked overall which they would choose most often

Route	Frequency
Summit Ave	50
I-94	45
Grand or Marshall/Selby	12 (6 Grand, 6 Marshall/Selby)
University Avenue	5

Inspection of Table 3.4 shows that 50 participants indicated that they would choose the Summit Avenue route, while 45 indicated they would chose the I-94 route. It also shows that they are far more likely to choose either Summit Avenue or I-94 than they are to choose the Grand Avenue, Marshall/Selby, or University Avenue routes.

<u>3.1.1.4 Route Preference</u>—The three slightly different ways of asking the participants which of the four routes they preferred produced similar results. When asked to rank the routes and when asked which route they would choose most often, the Summit Avenue route was narrowly favored over the I-94 route—and when asked which route they would drive tomorrow Summit Avenue and I-94 were tied. Further, the responses to all three questions showed that the Summit Avenue and I-94 routes were heavily favored at the expense of the other three routes.

Simply on the basis of these data, one might expect that the Summit Avenue and I-94 routes are very similar; however, when we turn to the other data collected in this study, it will become apparent that this is not the case

3.1.2 Perceived Experience of Driving Routes

In the *ranking* instrument, the participants were asked several questions about the experience of driving the four different routes. It is interesting to examine the answers to these questions while considering the preference data reported in the previous subsection.

For each of the four routes that they encountered, the participants were asked—(1) how many minutes it took to drive the route (i.e., perceived time); (2) how many miles they had to drive on the route (i.e., perceived distance); (3) the average speed while driving the route (i.e., perceived speed); and (4) the number of minutes they were stopped (because of traffic lights, ramp meters, or traffic congestion) while driving the route (perceived stopped time). A series of four ANOVAs were used to analyze the responses to these four questions. All four ANOVAs are summarized in Table 3.5.

Table 3.5: Summary of four ANOVAs—F-values (and *p*-values) for perceived time, perceived distance, perceived speed, and perceived stopped time

Source	Perceived Time	Perceived Distance	Perceived Speed	Perceived Stopped Time
Gender (G)	F=0.112 (*p*=0.7387)	F=0.177 (*p*=0.6744)	F=4.693 **(*p*=0.0324)**	F=0.320 (*p*=0.5724)
Grand Group vs. Marshall/Selby Group (GRP)	F=0.127 (*p*=0.7223)	F=1.478 (*p*=0.2268)	F=1.094 (*p*=0.2979)	F=0.032 (*p*=0.8565)
Routes (R)	F=117.335 **(*p*<0.0001)**	F=35.324 **(*p*<0.0001)**	F=762.628 **(*p*<0.0001)**	F=55.123 **(*p*<0.0001)**
Interaction of R x GRP	F= 0.450 (*p*=0.7173)	F= 2.772 **(*p*=0.0416)**	F=0.690 (*p*=0.5589)	F=1.678 (*p*=0.1714)
Interaction of R x G x GRP	F=1.150 (*p*=0.3291)	F=0.822 (*p*=0.4823)	F=0.3.409 **(*p*=0.0178)**	F=1.103 (*p*=0.3480

Table 3.5 shows that there were statistically significant differences (significant results are bolded) in the perceived time (*p*<0.0001), perceived distance (*p*<0.0001), perceived speed (*p*<0.0001), and perceived stopped time (*p*<0.0001), for the four routes—while the differences between the groups of participants who drove the Grand Avenue route and the Marshall/Selby route were not significantly different. There was a statistically significant difference between males and females in their perceived speed of the routes (*p*=0.0324). Females perceived their speed to be somewhat faster on each route than did males. Also, there was a statistically significant interaction for route and group for perceived distance (*p*=0.0416), as well as a statistically significant interaction for route and gender and group for perceived speed (*p*=0.0178).

The finding that there are statistically significant differences in the perceived time, perceived distance, perceived speed, and perceived stopped time between the various routes might be expected, given the differences in preference data reported in the previous subsection. And, subsequent *post hoc* analyses of the various data sets show that the perceived time was shorter, the perceived distance was shorter, the perceived speed was faster, and the perceived stopped time was shorter for the I-94 route than for the other routes. This might provide an explanation as to why the participants preferred the I-94 route over the University Avenue, Grand Avenue, and Marshall/Selby routes. However, it leaves unexplained why they chose the Summit Avenue route, which, as mentioned in the previous subsection, was narrowly favored over the I-94 route for two of the route preference questions and tied with I-94 for the third.

3.1.3 Route Characteristics

Participants were asked to respond—with both *rating* and *ranking* instruments—to a number of questions exploring various characteristics of the routes that they drove. It is interesting to examine the answers to the questions in order to determine whether or not these answers provide an explanation as to why the participants favored the Summit

Avenue route at least as much as the I-94 route, and to discover whether there were any similarities in the responses to those two routes.

3.1.3.1 Efficiency, Ease of Driving, and Pleasantness—For each of the routes that they encountered, the participants were asked, in the *rating* instrument, to "think of the route that you just drove as part of your commute to or from work" and rate it with regard to—(1) "its efficiency;" (2) "how easy it was to drive;" and (3) "how pleasant it seemed to be." Three ANOVAs were used to analyze the responses to these three questions for the participants who drove the Grand Avenue route and a separate set of three ANOVAs was done for those who drove the Marshall/Selby route. The results of the three ANOVAs conducted on the data from the participants in the Grand Avenue group are summarized in Table 3.6.

Table 3.6: Summary of three ANOVAs—F-values (and *p*-values) for ratings of efficiency, ease of driving, and pleasantness of the routes, for the participants who drove the Grand Avenue route

Source	Efficiency	Ease of Driving	Pleasantness
Gender (G)	F=0.986 (p=0.3247)	F=0.415 (p=0.5222)	F=0.311 (p=0.5794)
Routes (R)	F=40.638 **(p<0.0001)**	F=13.970 **(p<0.0001)**	F=80.938 **(p<0.0001)**
Interaction of G x R	F=0.195 (p=0.8997)	F=0.331 (p=0.8030)	F=0.550 (p=0.6488)

Table 3.6 shows that there were statistically significant differences in the efficiency ratings, the ratings for ease of driving the routes, and the ratings of the pleasantness of the routes (all at the p<0.001 level) for the participants who were in the group that drove the Grand Avenue route. The table also shows that there were no statistically significant gender differences and no significant interactions between the gender of the participants and the routes for any of the three variables.

The statistically significant differences shown in Table 3.6 are further explored in Table 3.7—which presents the average ratings for efficiency, ease of driving, and pleasantness that were obtained for each of the routes driven by the participants in the Grand Avenue group.

Table 3.7: Average ratings for efficiency, ease of driving, and pleasantness for each of the routes driven by the participants in the Grand Avenue group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	Efficiency	Ease of Driving	Pleasantness
Summit Avenue	4.92	6.45	5.55
I-94	6.52	4.40	5.40
University Avenue	4.40	3.37	1.94
Grand Avenue	4.27	5.92	4.68

Table 3.7 shows a different pattern of ratings for each aspect. First, examination of the ratings for *efficiency* indicates that the I-94 route was rated most highly, with an average rating of 6.52 (on the 7-point category scale), that the Summit Avenue route was rated second highest, with an average rating of 4.92, while the University Avenue and Grand Avenue routes received the poorest ratings for efficiency, with average ratings of 4.40 and 4.27, respectively. However, when the ratings for *ease of driving* are examined, it is clear that the Summit Avenue route was rated most highly, with an average rating of 6.45, that the Grand Avenue route was rated second highest, with an average rating of 5.92, while both the I-94 and University Avenue routes received poorer average ratings of 4.40 and 3.37, respectively. Finally with regard to the pleasantness of the route, both the Summit Avenue and I-94 routes received relatively high average ratings—of 5.55 and 5.40, respectively, while the Grand Avenue route was rated next highest, with an average rating of 4.68, and the University Avenue route was given a very low rating for pleasantness, with an average of only 1.94.

The three ANOVAs used to analyze the efficiency, ease of driving, and pleasantness responses for the participants who drove the Marshall/Selby route are summarized in Table 3.8.

Table 3.8: Summary of three ANOVAs—F-values (and *p*-values) for the ratings of efficiency, ease of driving, and pleasantness of the routes, for the participants who drove the Marshall/Selby route

Source	**Efficiency**	**Ease of Driving**	**Pleasantness**
Gender (G)	F=5.736 **(p=0.0201)**	F=4.132 **(p=0.0469)**	F=2.242 (p=0.1400)
Routes (R)	F=31.905 **(p<0.0001)**	F=13.268 **(p<0.0001)**	F=43.553 **(p<0.0001)**
Interaction of G x R	F=2.319 (p=0.0773)	F=3.407 **(p=0.0190)**	F=0.335 (p=0.7997)

Table 3.8 shows that, as for the Grand Avenue group, there were statistically significant differences in the efficiency ratings, the ratings for ease of driving the routes, and the ratings of the pleasantness of the routes (all at the p<0.001 level) for those participants in the group that drove the Marshall/Selby route. However, the table shows that there were also statistically significant gender differences for efficiency and ease of driving, at the p=0.0201 and p=0.0469 levels, respectively. In addition, there was a significant interaction (at the p=0.0190 level) of gender and routes for ease of driving.

Because of the two statistically significant gender effects and the significant interaction, the differences in efficiency, ease of driving, and pleasantness responses are further explored in Table 3.9, for the female participants, and Table 3.10, for the males who were in the Marshall/Selby group.

Table 3.9: Average ratings for efficiency, ease of driving, and pleasantness for each of the routes driven by the *female* participants in the Marshall/Selby group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	Efficiency	Ease of Driving	Pleasantness
Summit Avenue	5.00	5.50	6.21
I-94	5.89	5.89	4.18
University Avenue	4.25	4.89	3.71
Marshall/Selby	3.68	4.07	4.93

Table 3.10: Average ratings for efficiency, ease of driving, and pleasantness for each of the routes driven by the *male* participants in the Marshall/Selby group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	Efficiency	Ease of Driving	Pleasantness
Summit Avenue	5.17	5.79	6.31
I-94	6.41	5.98	4.36
University Avenue	4.59	5.00	4.05
Marshall/Selby	4.90	5.38	5.45

The rating data for the participants in the Marshall/Selby group shown in Tables 3.9 and 3.10 show a different pattern of ratings for each aspect. Examination of the ratings for *efficiency* indicates that the I-94 route was rated most highly, with average ratings of 5.89 and 6.41 for the females and males, respectively, that the Summit Avenue route was rated second highest, with average ratings of 5.00 and 5.17 for the females and males, respectively, while the poorest ratings were received by the University Avenue route (with 4.25 for females and 4.59 for males) and the Marshall/Selby route (which was rated considerably lower, at 3.70, for females than it was, at 4.90, for males). When the ratings for *ease of driving* are examined, it is clear that the I-94 route was rated most highly by both females (5.89) and males (5.98), the Summit Avenue route was rated second highest by both females (5.50) and males (5.79), while the poorest ratings were received by the Marshall/Selby route (with 4.07 for females and 5.40 for males) and the University Avenue route (with 4.89 for females and 5.00 for males. With regard to the pleasantness of the route, the Summit Avenue route received the highest average ratings (6.21 for females and 6.31 for males), while the Marshall/Grand route was rated second highest (4.93 for females and 5.45 for males), the I-94 route was rated third highest (4.20 for females and 4.36 for males), and the University Avenue route was given the poorest rating for pleasantness (3.71 for females and 4.05 for males).

In summary, the ratings for efficiency, ease of driving, and pleasantness suggest why the Summit Avenue route did so well in participant responses to the three preference questions, where it was narrowly favored over the I-94 route for two of the route preference questions and tied with it for the third. The Summit route was rated the second most efficient, by the participants in both the Grand Avenue and the

Marshall/Selby groups, the easiest (the Grand Avenue group) or second easiest (the Marshall/Selby group) to drive, and the most pleasant route by the participants in both the Grand Avenue and the Marshall/Selby groups. Also, the ratings for efficiency, ease of driving, and pleasantness received by the I-94 route provide further information as to why this route also did well in the answers to the three preference questions.

3.1.3.2 Commuting—Each participant was also asked, in the *rating* instrument to think of each route they drove "as part of your commute to or from work." Then, the participant was asked how he or she "would rate driving a route very much like" it—(1) to work, "assuming *no stops* for shopping, daycare, and the like"; (2) to work, assuming that he or she would "make *typical stops* for shopping, daycare, and the like"; (3) home from work, "assuming *no stops* for shopping, daycare, and the like"; and (4) home from work assuming that he or she would "make *typical stops* for shopping, daycare, and the like." Four ANOVAs were conducted in order to analyze the responses to these four questions for the participants who drove the the Grand Avenue route and four ANOVAs were conducted for those who drove the Marshall/Selby route. The results of the four ANOVAs conducted on the data from the participants in the Grand Avenue group are summarized in Table 3.11; while those conducted on the data from the participants in the Marshall/Selby group are summarized in Table 3.12.

Table 3.11: Summary of four ANOVAs—F-values (and *p*-values) for the ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Grand Avenue group

Source	**To Work: No Stops**	**To Work: Typical Stops**	**To Home: No Stops**	**To Home: Typical Stops**
Gender (G)	F=1.689 (*p*=0.1988)	F=3.053 (*p*=0.0859)	F=1.024 (*p*=0.3160)	F=2.393 (*p*=0.1275)
Routes (R)	F=20.367 **(*p*<0.0001)**	F=8.502 **(*p*<0.0001)**	F=21.751 **(*p*<0.0001)**	F=11.888 **(*p*<0.0001)**
Interaction of G x R	F=0.892 (*p*=0.4464)	F=0.120 (*p*=0.9484)	F=0.672 (*p*=0.5705)	F=0.038 (*p*=0.9899)

Table 3.12: Summary of four ANOVAs—F-values (and *p*-values) for the ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Marshall/Selby group

Source	**To Work: No Stops**	**To Work: Typical Stops**	**To Home: No Stops**	**To Home: Typical Stops**
Gender (G)	F=0.303 (*p*=0.5640)	F=0.201 (*p*=0.6557)	F=1.136 (*p*=0.2912)	F=0.451 (*p*=0.5047)
Routes (R)	F=12.818 **(*p*<0.0001)**	F=3.887 **(*p*=0.0102)**	F=15.922 **(*p*<0.0001)**	F=4.060 **(*p*=0.0082)**
Interaction of G x R	F=1.433 (*p*=0.4464)	F=1.262 (*p*=0.2894)	F=01.144 (*p*=0.3333)	F=0.038 (*p*=0.9899)

Tables 3.11 and 3.12 show that there were statistically significant differences in the ratings of the routes when they were considered for commuting to work with no stops ($p<0.0001$ for both the Grand Avenue and Marshall/Selby groups), for commuting to work making typical stops ($p<0.0001$ for the Grand Avenue group and $p=0.0102$ for the Marshall/Selby group), for commuting home with no stops ($p<0.0001$ for both the Grand Avenue and Marshall/Selby groups), and for commuting home with typical stops ($p<0.0001$ for the Grand Avenue group and $p=0.0082$ for the Marshall/Selby group). The two tables also show that there were no statistically significant gender differences and that there were no significant interactions between the gender of the participants and the routes in either the Grand Avenue or the Marshall/Selby groups.

The statistically significant differences indicated in Tables 3.11 and 3.12 are further explored in Tables 3.13 and 3.14—which present the average ratings for commuting to work with no stops, for commuting to work making typical stops, for commuting home with no stops, and for commuting home with typical stops, for both the Grand Avenue and the Marshall/Selby groups.

Table 3.13: Average ratings of the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Grand Avenue group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	**To Work: No Stops**	**To Work: Typical Stops**	**To Home: No Stops**	**To Home: Typical Stops**
Summit Avenue	5.55	4.82	5.65	4.86
I-94	5.40	3.67	5.16	3.54
University Avenue	3.61	4.00	3.40	3.98
Grand Avenue	4.68	4.90	4.79	5.09

Table 3.14: Average ratings for the routes for commuting to work with no stops and with typical stops, and for returning home with no stops and with typical stops—for the Marshall/Selby group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	**To Work: No Stops**	**To Work: Typical Stops**	**To Home: No Stops**	**To Home: Typical Stops**
Summit Avenue	5.32	4.84	5.58	4.82
I-94	4.86	4.05	4.80	3.95
University Avenue	3.82	4.11	3.71	4.00
Marshall/Selby	4.25	4.12	4.46	4.16

Inspection of Tables 3.13 and 3.14 reveals that the tables do not tell exactly the same story.

Table 3.13 shows that, when the participants in the Grand Avenue group consider commuting to work or to their home with *no stops*, they give the Summit Avenue route the highest ratings, the I-94 route the second highest ratings, the Grand Avenue route the third highest ratings, and the University Avenue route the worst ratings. However, when the participants in the Grand Avenue group consider commuting to work or to their home when they would make *typical stops* for shopping, daycare, and the like, the order changes—now, they give the Grand Avenue route the highest ratings, the Summit Avenue route the second highest ratings, the University Avenue route the third highest ratings, and the I-94 the worst ratings.

In contrast, as Table 3.14 shows, when the participants in the Marshall/Selby group consider commuting to work or to their home with *no stops*, they give the Summit route the highest ratings, the I-94 route the second highest ratings, the Marshall/Selby route the third highest ratings and the University Avenue route the worst ratings. But, when the participants in the Marshall/Selby group consider commuting to work or to their home when they would make *typical stops*, the order changes. They again give the Summit Avenue route the highest ratings, but the ratings for the other three routes are almost identical (ranging from 4.05 to 4.11 for the commute to work; and from 3.95 to 4.16 for the commute home).

In summary, the ratings for commuting to work with no stops, for commuting to work making typical stops, for commuting home with no stops, and for commuting home with typical stops provide further information as to why the Summit Avenue route did so well in the answers to the three preference questions.

<u>3.1.3.3 Other Trips</u>—In the last section of the *rating* instrument, each participant was asked how he or she "would rate driving a route like this for"—(1) shopping; (2) going to the theater or a movie; (3) visiting family or friends; (4) going to a park; and (5) a Sunday drive—before being asked whether anything unusual occurred when driving the route. Five ANOVAs were conducted in order to analyze the responses to these five questions for the participants who drove the Grand Avenue route and five ANOVAs were conducted for those who drove the Marshall/Selby route. The results of the five ANOVAs conducted on the data from the participants in the Grand Avenue group are summarized in Table 3.15.

Table 3.15 shows that there were statistically significant differences in the ratings of the routes when they were considered for shopping, going to a theater or movie, visiting family or friends, going to a park, and taking a Sunday drive (all at the $p<0.0001$ level). The table also shows that there were no statistically significant gender differences and no significant interactions between the gender of the participants and the routes for the Grand Avenue group.

Table 3.15: Summary of five ANOVAs—F-values (and *p*-values) for the ratings of the routes for shopping, going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive—for the Grand Avenue group

Source	**Shopping**	**Theater or Movie**	**Visit Family or Friends**	**Going to a Park**	**Sunday Drive**
Gender (G)	F=1.103 (p=0.2981)	F=0.497 (p=0.4836)	F=0.003 (p=0.9577)	F=0.357 (p=0.1275)	F=0.002 (p=0.9667)
Routes (R)	F=10.325 **(p<0.0001)**	F=13.111 **(p<0.0001)**	F=31.775 **(p<0.0001)**	F=68.238 **(p<0.0001)**	F=149.252 **(p<0.0001)**
Interaction of G x R	F=1.198 (p=0.3122)	F=0.639 (p=0.5907)	F=0.198 (p=0.8977)	F=0.419 (p=0.7396)	F=0.432 (p=0.7305)

The statistically significant differences shown in Table 3.15 are explored in Table 3.16. The table presents the average ratings for shopping, going to a theater or movie, visiting family or friends, going to a park, and taking a Sunday drive for the participants in the Grand Avenue group.

Table 3.16: Average ratings of the routes for shopping, going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive—for the Grand Avenue group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	**Shopping**	**Theater or Movie**	**Visit Family or Friends**	**Going to a Park**	**Sunday Drive**
Summit Avenue	4.44	4.48	5.42	6.17	6.49
I-94	4.05	4.37	4.97	4.09	2.44
University Avenue	4.25	3.32	3.22	2.93	2.19
Grand Avenue	5.58	5.09	5.07	5.57	5.71

Interestingly, Table 3.16 shows that the Grand Avenue route received the highest ratings when considered for the purposes of shopping and going to the theater or a movie, with the Summit Avenue route receiving the second highest ratings in both cases. However, when the routes were considered for the purposes of visiting family or friends, going to a park or taking a Sunday drive, the Summit Avenue route was given the highest ratings, and the Grand Avenue route received the second highest ratings. The table also shows that for the participants in the Grand Avenue group, the I-94 route received only the third highest ratings when considered for going to a theater or movie, visiting family or friends, going to a park, and taking a Sunday drive and it received the worst ratings when considered for shopping. And the University route received the worst ratings for going to a theater or movie, visiting family or friends, going to a park, and taking a Sunday drive, and the third highest for shopping.

Table 3.17 below shows the results of the five ANOVAs conducted on the data from the participants in the Marshall/Selby group.

Table 3.17: Summary of five ANOVAs—F-values (and *p*-values) for the ratings of the routes for shopping, going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive—for the Marshall/Selby group

Source	**Shopping**	**Theater or Movie**	**Visit Family or Friends**	**Going to a Park**	**Sunday Drive**
Gender (G)	F=0.001 (*p*=0.9800)	F=0.092 (*p*=0.7627)	F=0.003 (*p*=0.9577)	F=0.044 (*p*=0.8338)	F=2.927 (*p*=0.0930)
Routes (R)	F=1.112 (*p*=0.3460)	F=4.443 **(*p*=0.0050)**	F=13.885 **(*p*<0.0001)**	F=34.343 **(*p*<0.0001)**	F=103.204 **(*p*<0.0001)**
Interaction of G x R	F=3.290 **(*p*=0.0222)**	F=0.639 (*p*=0.5907)	F=2.072 (*p*=0.1060)	F=1.265 (*p*=0.2883)	F=1.553 (*p*=0.2081)

Table 3.17 shows that there were statistically significant differences in the ratings of the routes when they were considered for going to a theater or movie, visiting family or friends, going to a park, taking a Sunday drive (all at the *p*<0.0001 level). The table also shows that there were no statistically significant gender differences. However, when the routes were considered for the purposes of shopping, there was no statistically significant effect of either gender or routes, but there was a significant interaction between the two variables. The interaction is explored in Table 3.18.

Table 3.18: Average ratings of the routes shopping for the female and male participants in the Marshall/Selby group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	**Female**	**Male**
Summit Avenue	4.70	3.97
I-94	4.37	3.90
University Avenue	4.07	4.66
Marshall/Selby	3.59	4.24

Table 3.18 shows that the female participants rated the Summit Avenue and I-94 routes higher for shopping than the University Avenue and the Marshall/Selby routes—however, the opposite was the case for the male participants.

The statistically significant differences in main effects for routes are explored in Table 3.19. The table presents the average ratings for going to a theater or movie, visiting family or friends, going to a park, and taking a Sunday drive for the participants in the Marshall/Selby group.

Table 3.19: Average ratings of the routes going to the theater or a movie, visiting family or friends, going to a park, or a Sunday drive—for the Marshall/Selby group. [Please note: Individual participant ratings range from 1 – 7, with "1" reflecting the *least* favorable rating and "7" reflecting the *most* favorable.]

Route	**Theater or Movie**	**Visit Family or Friends**	**Going to a Park**	**Sunday Drive**
Summit Avenue	4.57	5.11	5.75	6.47
I-94	4.39	4.64	3.70	2.56
University Avenue	3.88	3.64	3.38	2.51
Marshall/Selby	3.86	4.27	4.45	4.78

Table 3.19 shows that the Summit Avenue route received the highest ratings when considered for the purposes of going to the theater or a movie, visiting family or friends, going to a park or taking a Sunday drive. The I-94 route received the second highest ratings when considered for going to a theater or movie, and the Marshall/Selby route received the second highest ratings when considered for visiting family or friends or taking a Sunday drive. Table 3.19 also shows that for the participants in the Grand Avenue group, the University route received the worst ratings for going to a theater or movie, visiting family or friends, going to a park, and taking a Sunday drive.

In summary, the ratings for the other trips considered in this subsection—shopping, going to the theater or a movie, visiting family or friends, going to a park or taking a Sunday drive—provide still more information as to why the Summit Avenue route did so well in the answers to the three preference questions.

3.1.3.4 Other Trips (Rankings)—In addition to *ratings*, towards the end of the survey instrument participants also *ranked* the routes in terms of various purposes. Each participant was asked to rank the four routes that he or she had driven when considering using them for—(1) commuting; (2) shopping; (3) going to a special event; (4) taking a recreational trip; (5) visiting family or friends; and (6) going on a Sunday drive. The average rankings for the participants in the Grand Avenue and Marshall/Selby groups are presented in Tables 3.20 and 3.21. When looking at these two tables, it should be remembered that the lower scores reflect a higher ranking.

In Table 3.20, which has the average rankings for the Grand Avenue group, the Summit Avenue route has the best average rankings for four of the categories (going to a special event, taking a recreational trip, visiting family or friends, and going on a Sunday drive), while the I-94 route has the best average ranking for commuting and the Grand Avenue route has the best average ranking for shopping. Also, the table shows that although the University Avenue route had the second best average ranking for shopping, it had the lowest average ranking in the other five categories (commuting, going to a special event, taking a recreational trip, visiting family or friends, and going on a Sunday drive).

Table 3.20: Average *rankings* of the routes considered for commuting, shopping, going to a special event, taking a recreational trip, visiting family or friends, or taking a Sunday drive—for the Grand Avenue group. [Please note: Participants were instructed to rank the routes from 1 - 4, with "1" reflecting the *most* favorable and "4" indicating the *least* favorable.]

Route	Commute	Shopping	Special Event	Recreational Trip	Visiting Family/ Friends	Taking Sunday Drive
Summit Avenue	2.13	2.62	2.03	1.32	1.82	1.13
I-94	1.57	3.15	2.08	3.05	2.05	3.42
University Avenue	3.27	2.60	3.28	3.57	3.65	3.57
Grand Avenue	3.03	1.63	2.57	2.10	2.47	1.88

Table 3.21: Average *rankings* of the routes considered for commuting, shopping, going to a special event, taking a recreational trip, visiting family or friends, or taking a Sunday drive—for the Marshall/Selby group. [Please note: Participants were instructed to rank the routes from 1 - 4, with "1" reflecting the *most* favorable and "4" indicating the *least* favorable.]

Route	Commute	Shopping	Special Event	Recreational Trip	Visiting Family/ Friends	Taking Sunday Drive
Summit Avenue	2.29	2.59	2.14	1.36	1.80	1.14
I-94	1.55	2.54	1.71	2.96	1.93	3.43
University Avenue	3.14	2.14	3.04	3.34	3.27	3.27
Marshall/Selby	2.98	2.63	3.07	2.32	2.89	2.11

The pattern of the ranking data obtained for the Grand Avenue group is very similar to the pattern found in Table 3.21, for the Marshall/Selby group. In this table, the Summit Avenue route has the best rankings for three of the categories (taking a recreational trip, visiting family or friends, and going on a Sunday drive), while the I-94 route has the best ranking for commuting and going to a special event. Table 3.21 also shows for the participants in the Marshall/Selby group that while the University Avenue route had the best average ranking for shopping, it had the lowest average ranking in three of the other five categories (commuting, taking a recreational trip, and visiting family or friends), and had only the third highest ranking in the other two (going to a special event, and going on a Sunday drive).

3.2 The Value of Travel-time Information

3.2.1 Using Travel-Time Information

In addition to determining the route preferences of drivers who drove on selected real-world roads, another objective of this study was to determine the usefulness of travel-time information to drivers who drove the roads. Half of the participants in the study were given travel-time information before they began driving each route and they were asked to assess its usefulness after they had driven them.

When asked whether they would use travel-time information like that provided in the study if it were available in making a choice between routes 40 of 54 participants (74%) answered that they would. Those who said they would use travel-time information were asked how often they would use it—the responses to this question are presented in Table 3.22.

Table 3.22: Responses to question about frequency of use of travel-time information

Frequency of Use	Number
Several Times a Day	5
Once Per Trip	16
Once Per Day	3
3-6 Times a Week	6
Once a Week	4
Less than Once a Week	5
Total	**39**

Table 3.22 shows that 16 of the 39 participants (41%) said that they would use travel-time information once per trip.

Next the participants who received travel-time information were asked to rank how useful it would be for several types of trips. The average rankings they gave in response to this question are presented in Table 3.23. [Again, lower scores reflect a higher ranking.] Table 3.23 shows that when considering the usefulness of travel-time information, the participants gave the highest rank to commuting, with the second highest rank to special events. Perhaps not surprisingly, the lowest rank was given to the Sunday drive. An abnormal result in Table 3.23 should be pointed out. Eight subjects believe that information is least important for commute trips. Four of them generally walk, bike, or carpool (as passengers) to work.

When asked how much they would be willing to pay for travel-time information, 40 of the 50 participants (80%) who responded to this question said zero. The other 10 responses are difficult to categorize—some indicated how much they would be prepared to pay per trip, others responded with how much they would be prepared to pay per day; it is unclear how often the remaining respondents thought they would pay.
To compare, Wolinetz *et al.* (2001) found that 48.5% survey participants are willing to pay for traveler information. It is not surprising that a larger percentage is found in their

study because respondents were notified that they would receive information for both their usual routes and alternative routes.

Table 3.23: Average rankings of the usefulness of travel-time information for six types of trips. [Please note: Participants were instructed to rank the routes from 1 - 4, with "1" reflecting the *most* favorable and "4" indicating the *least* favorable.]

Purpose	**Commute**	**Event**	**Shopping**	**Recreation**	**Visit**	**Sunday**
Ranked first	31	10	2	2	3	5
Ranked second	4	25	10	6	5	1
Ranked third	1	6	18	13	12	3
Ranked fourth	3	8	5	19	11	4
Ranked fifth	3	1	14	9	16	5
Ranked last	8	1	1	0	3	32
Average rank	2.34	2.40	3.42	3.58	3.79	4.98
Effective sample size: 50						

The next question dealt with how travel-time information should be provided. The participants were asked whether it should be provided free by the public sector, at a charge by the private sector, or not at all. The responses are presented in Table 3.24.

Table 3.24: Responses to question about provision of travel-time information

Provision of Travel-time Information	**Number**
Free by Public Sector	35
At Charge by Private Sector	9
Not at All	7
Total	**51**

Table 3.24 shows that 35 of the 51 participants (68.6 %) who responded to this question think that travel-time information should be provided free by the public sector. Further, only 9 of 51 (17.6 %) think that it should be provided at a charge by the private sector.

3.2.2 The Effect of Providing Travel-time Information

Finally, we conducted a series of twelve ANOVAs to determine whether providing travel-time information had an effect on the ratings provided by the participants in the study. The results of these ANOVAs showed that the provision of travel-time information did not produce statistically significant effects on the ratings obtained for—

(1) efficiency; (2) ease of driving; (3) the pleasantness of the routes; (4) commuting to work with no stops; (5) commuting to work with typical stops; (6) commuting home with no stops; (7) commuting home with typical stops; (8) going to the theater or a movie; (9) visiting family or friends; (10) going to a park; or (11) taking a Sunday drive. It did have an effect on the ratings obtained when the participants rated the routes for shopping (at the p=0429 level). The overall average ratings were 4.39 when the participants had no travel-time information and 4.10 when they did not. While this is a statistically significant difference, it does not appear to have any practical importance.

3.3 Summary

In summary, two specific objectives of the study were—

- To determine the route preferences of drivers who drove on selected real-world roads.
- To determine the usefulness of travel-time information to drivers who drove on selected real-world roads.

We selected several alternative routes between the University of Minnesota in Minneapolis and the Cathedral of St. Paul in St. Paul. The routes included a freeway, an arterial road, a parkway, and urban roads—they all have very different characteristics. They are roughly parallel to each other geographically and they provide reasonable alternative routes to travel between the two locations. After driving four of these routes consecutively within a two-hour period on a weekday (Monday, Tuesday, Wednesday, or Thursday), the subjects participating in the study were asked to state their route preferences. In addition, half the subjects were given travel-time information before they began driving each route, and asked to assess its usefulness after they had driven them.

The results revealed that two routes—I-94 and Summit Avenue—were clearly preferred to the other routes when rated and ranked on a number of dimensions. I-94 is a freeway with three to four lanes in each direction. It is now the main route between Minneapolis and St. Paul. In contrast, Summit Avenue has a parkway or boulevard character, much of which is lined with grass and trees and some of which has a wide grass-covered central island with many trees. It has a number of intersections with traffic lights.

The participants indicated that I-94 took less time to drive, was shorter in distance, could be driven faster, and had less stopped time than Summit and the other three routes. Consequently, the finding that Summit Avenue is preferred as much if not more than I-94 indicates that speed and efficiency are not the only dimensions on which people make their route choices. Possible explanations as to why Summit Avenue was favored so highly are found in the ratings and rankings pertaining to a variety of road attributes or dimensions, including efficiency, ease of driving, and pleasantness of the route.

With regard to travel-time information, while 74% of the participants said they would use the information, a full 80% said the cost they were willing to pay for the information is zero, and 68.6% said that it should be provided free by the public sector. Clearly, this result shows that people would appreciate travel-time information to facilitate their route choice and they would like the information to be provided free of charge.

CHAPTER 4
ANALYTICAL MODEL METHODOLOGY

To further understand the relationship between the variables and explain route preferences, two sets of statistical models are derived. The first set of models (section 4.1) describes how drivers' route preferences vary with the presence and accuracy of information, while controlling for observed or perceived route attributes such as travel time, number of stops, stopped delay, specific route, car (make, model, age of car etc.), and demographics (age, male/female, household size etc.). The second set of models (section 4.2) correlates drivers' propensity to the usage of traveler information with the quality of information and drivers' attitudes, socio-economic, demographic, travel behavioral, and other factors.

4.1 Route Choice and Traveler Information

Choice behavior in the transportation literature is often depicted as a two-stage process. First, a choice-set generation process determines the feasible alternatives known and considered by the decision maker for a choice situation. Then a choice criterion is assumed which eliminates inferior alternatives until the best alternative is identified. Dominance, satisfaction, lexicographic rules, elimination by aspects, heuristic production rules (if…then…), and utility-maximization are the most common decision protocols (Slovic *et al.,* 1977; Svenson, 1979; Ben-Akiva & Lerman, 1985; Arentze & Timmermans, 2000). The analysis of route choice behavior in this report assumes that travelers are utility maximizers. Future research may develop route choice models based on the same dataset and other decision criteria and make comparisons.

Random utility theory (Manski, 1977) states that utility has two parts, an observable deterministic component and an unobservable random component. The probability of choosing an alternative is equal to the probability that the utility of that alternative is greater than or equal to the utilities of all other considered alternatives. The deterministic or systematic utility of a route being considered by a traveler is:

$$U = f(T, V, I, A, P, R, N, D, K, E, B, Q, C, S, H, F, \mathbf{X}) \qquad (1)$$

Where

T: Travel time;
V: Variation in travel time from expectations;
I: Pre-commute information about travel time (with or without);
A: Accuracy of information (rated on a 1~7 scale by subjects & measured by GPS);
P: Trip purpose;
R: Number of stops;
N: Number of turns;
D: Total delay;
K: Density of surrounding traffic;
E: Environmental factors (weather etc.);
B: Road type (residential, signalized arterial, freeway, etc.);

Q: Aesthetic quality of the roadside environment (high or low);
C: Level of commercial development along the route (high or low);
S: Safety of the road (accidents etc.)
H: Hour of the day (personal safety concerns etc.)
F: Familiarity with the route (rated on a 1~7 scale);
X: Socio-economic and demographic factors describing individual driver.

The method most widely used to operationalize random utility theory is discrete choice modeling. McFadden (1974) applied the logit model to prediction of individual mode choice. Discrete choice models have been continuously improved to address many econometric issues. Binary, multinomial, and rank-ordered logit models are specified in this study to deal with different response variables.

Each subject ranked the four routes traveled for different trip purposes. The rank-ordered logit model takes the rank of routes as the dependent variable. It is sometimes referred to as the Placket-Luce or exploded logit model. Rank-ordered choice models are of particular interest in survey research because of their cost-effectiveness. They fully utilize the ranks of all alternatives rather than just the most preferred one as in multinomial logit models, so that more information is collected per observation (Koop & Porier, 1994). The probability (*P*) that a subject ranks all four alternatives in a choice set in a specific order *w* is:

$$P[W = w \mid \beta] = \prod_{i=1}^{4} \frac{\exp(U_{w_i})}{\sum_{w_i}^{w_4} \exp(U_{w_i})} \tag{2}$$

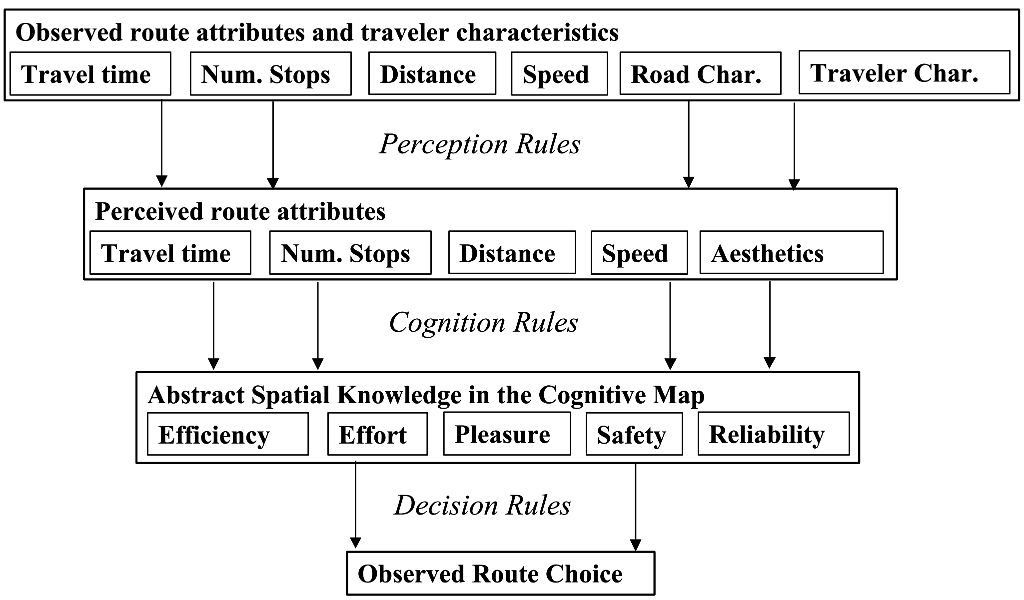
w_i is the i^{th} alternative in the ranking. If choice *i* is the most preferred and has been ranked first, the choice that is ranked second would then be the most preferred among the remaining alternatives. The probability density and log-likelihood functions of a rank ordered logit model are similar to those of a traditional multinomial logit model. One concern with ranked responses is that the subjects may only care about the most preferred alternative and thus the rank information for the remaining alternatives may not be reliable. For confirmation purposes, we therefore also estimated multinomial logit models in which the information about the relative desirableness of the three unselected alternatives is not utilized.

Discrete choice models consider utility as an *ordinal* measure. The notion of *cardinal* utility is sometimes useful. Since the subjects also rated the routes on a 1~7 scale besides ranking the routes. We can consider the rated score as a cardinal utility measure. In that case, an ordinary regression model can be specified based on equation (1) directly for each route and for each trip purpose. This not only provides a means to confirm results obtained from the discrete choice models, but also allows us to examine the variation of the value of information by route attributes. However, the scores rated by the subjects tend to display different means and variations. In order to avoid issues related to non-zero mean and heteroscedasticity, the scores are standardized for each individual subject, and the standardized score is used as the dependent variable in the regression models.

In order to operationalize the proposed theory of route choice, the perception and cognition processes for learning routes in a network and route attributes must be explicitly modeled. Figure 4.1 shows how a traveler makes a route-choice decision, given actual attributes of one or more routes. Various protocols of choice act mentioned earlier in this section relate the objective reality, i.e. observed route attributes, to the final choice in different ways. But they in general ignore the perception and cognition processes.

The statistical models described above can identify the importance of various factors on route preference. The elasticity between information and travel cost derived from the models should provide a way of measuring the value of traveler information differentiated by trip purposes, and by various route attributes.

Figure 4.1. Route perception and cognition



4.2 Information Usage and Public Acceptance of Traveler Information Systems

The success of ATIS depends on the public acceptance of and demand for the technology. ATIS service providers, private or public, want to know the characteristics of drivers who are likely to frequently use traveler information. In order to address those issues, a number of questions regarding the usage of, attitude toward, and willingness to pay for traveler information services are included in the after-experiment survey. Summaries of the subjects' answers to these questions are provided in the previous section. A binary choice model is also specified to examine the factors affecting the usage of traveler information (1: will use traveler information; 0: will not). The utility of driving with or without traveler information is:

$$U = f(A, G, F, L, Z, \mathbf{M}, \mathbf{X}) \quad (3)$$

Where

A: Accuracy of information;

G: Attitude toward traveler information (perceived usefulness);

F: Familiarity with alternative routes;

L: Level of congestion;

Z: Perceived information acquisition and processing cost;

M: Travel patterns (commute time, distance, trip frequency etc.)

X: Socio-economic and demographic factors describing individual driver.

Perceived information acquisition and processing cost should have a negative impact on the usage of traveler information. In the experiment, information is provided to the subjects for free. Therefore, *Z* in this case is simply the perceived information processing cost, which is unobservable and becomes a part of the random component in the model. But its average effects on information usage should contribute to the constant term in the binary choice model.

An ordinary regression model can also be specified and estimated with the frequency of using information (*Y*) as the dependent variable (rated on a 1~6 scale where 1: less than once per week, and 6: several times per day).

$$Y = f(A, G, F, L, Z, \mathbf{M}, \mathbf{X}) \quad (4)$$

Results of regression model (4) should agree with the results of the binary logit model based on utility function (3) if subjects provided consistent answers in the survey.

CHAPTER 5
ANALYTICAL MODEL RESULTS

5.1 Importance of Various Route Attributes for Trips with Different Purposes

All coefficients in the rank-ordered, multinomial, and ordinary regression models of route choice have expected signs. For all trip purposes, drivers are more likely to choose a route that has (observed and perceived) lower travel time, higher speed, fewer number of stops, and better aesthetics (Tables 5.1a, 5.1b, 5.2a, and 5.2b). Drivers also prefer routes that are efficient, easy to drive, pleasant, and familiar (Tables 5.1c, 5.2c, and 5.3). The only exception is that the variable "actual distance" has positive signs in Tables 5.1a and 5.2a. The fact that all five routes selected for the field experiment have very similar total distance may cause the unexpected signs. However, variable "perceived distance" in general has expected negative signs in Tables 5.1b and 5.2b. Clearly, the perceived distance is different from the actual distance traveled. Subjects seem to have perception biases and have systematically misperceived the distances of some routes. The relationship between actual and perceived route attributes is the topic of an ongoing study.

It is also evident from the results that the importance of route attributes (actual and perceived) varies with trip purposes. Efficiency-related attributes such as travel time, distance, and number of stops are considered more important for commute, event and visit trips, less important or even insignificant for shopping and recreational trips. Enhanced road-side aesthetics makes a route more attractive for all types of trips, and has the most significant impacts on recreational trips. Level of commercial development is positively related to the attractiveness of route for shopping trips, while its impacts on other types of trips are not significant. There is also evidence of habitual route-choice behavior, especially for trips with time pressure. When making commute, event and visit trips, drivers tend to choose a route they are more familiar with than unfamiliar routes. One explanation is that under time pressure, drivers prefer a more reliable route, and they perceive routes they are familiar with and have used before as more reliable. Another explanation is the anchoring effects of "first-noticed routes" as discussed in Golledge (1996). Once a driver becomes familiar with a route, he or she has little incentive to switch to a new route with comparable or even slightly better performance because of perceived information acquisition and processing cost, perception threshold, and risk averseness. Several previous studies suggest that travel time is only one of many factors affecting route choice (Benshoof,1970, Vaziri & Lam, 1983; Ben-Akiva *et al.,* 1984; Bovy & Stern, 1990; Golledge, 1996), and that the relative importance of those factors vary by trip purposes (Wachs, 1967; Ulrich, 1974), type of driver (Stern & Leiser, 1988), trip distance, and duration (Stern & Leiser, 1989). Findings in this and previous research clearly show that route choice is a complex spatial behavior sensitive to a number of attributes of the environment and the decision maker. It is therefore a challenging task to develop a universal route choice theory that encompasses the aforementioned empirical evidence and still produces operational models. Traditional route assignment models considering only travel time, however, may have over-simplified the problem.

Table 5.1. Results: rank-order logit models

5.1a. Route Rank = f (Observed route attributes, Dummy Var., Information)

Purpose	Commute Trips	Event	Shopping	Recreation	Visit
Aesthetics	.69***	.81***	-.04	2.46***	1.30***
Commercial	.22	.72***	1.31***	1.29***	.78***
Time	-.14***	-.07**	.05	.05	-.07**
Distance	.41***	.15	-.15	.12	.38***
Num. Stops	-.08*	-.07	-.03	-.06	-.10**
Information	.81**	.33	.42	.28	-.00
LR Chi^2	110	68	38	180	104
Value of Info	6 min	-	-	-	-

5.1b. Route Rank = f (Perceived route attributes, Dummy Var., Information)

Purpose	Commute Trips	Event	Shopping	Recreation	Visit
Aesthetics	.80***	.77***	.14	2.60***	1.56***
Commercial	.02	.48**	1.52***	1.53***	.93***
Time	-.17***	-.07***	.00	-.00	-.11***
Distance	-.05	.05	.00	.12**	.02
Num. Stops	-.17***	-.12***	-.04	-.06	-.10**
Information	.85**	.63*	.37	.36	.12
LR Chi^2	190	84	47	194	138
Value of Info	5 min	9 min	-	-	-

5.1c. Route Rank = f (Cognitive knowledge, Dummy Var., Information)

Purpose	Commute Trips	Event	Shopping	Recreation	Visit
Aesthetics	.07	.34	-.24	1.6***	1.00***
Commercial	-.42	.19	1.26***	.77***	.61**
Efficiency	.58***	.27***	.02	-.16*	.37***
Easiness	.36***	.19*	.14	.15	.11
Pleasure	.30***	.22***	.14**	.49***	.23***
Unfamiliarity	-.42***	-.22***	.04	-.02	-.14**
Information	.37	.19	.17	-.03	-.21
LR Chi^2	247	124	59	238	156

*, **, ***: Statistically significant at levels 0.1, 0.05, 0.01 respectively

Table 5.2. Results: Multinomial logit models

5.2a. Route Choice = f (Observed route attributes, Dummy Var., Accurate Information)

Purpose	Commute Trips	Event	Shopping	Recreation	Visit
Aesthetics	1.08***	1.68***	-.56	3.60***	2.13***
Commercial	-1.45	.78	1.65***	.53	.13
Time	-.32***	-.27***	.07	-.01	-.25***
Distance	.80***	.61***	-.13	.43**	.88***
Num. Stops	-.01	.01	-.04	-.11*	-.07
Unfamiliarity	-.26***	-.13**	-.08	-.02	-.14**
Information	.26*	.24*	.13	.19	.11
Constant	.01	-.55	-.76	-4.4***	-2.29***
Psudo-R^2	.31	.19	.08	.37	.24
Value of Info	1 min	1 min	-	-	-

5.2b. Route Choice = f (Perceived route attributes, Dummy Var., Accurate Information)

Purpose	Commute Trips	Event	Shopping	Recreation	Visit
Aesthetics	1.63***	1.9***	-.45	3.9***	2.6***
Commercial	-1.37	1.0**	1.76***	1.0**	.51
Time	-.10***	-.04*	-.02	-.04	-.10***
Distance	-.06*	-.01	-.04**	.01	-.05
Speed	.08***	.07***	-.02*	.02	.05***
Num. Stops	-.13*	-.18***	-.05	-.04	-.13*
Information	.42***	.43***	.10	.21	.25
Constant	-2.07**	-3.0***	.42	-2.6**	-1.5
Psudo-R^2	.34	.21	.10	.36	.24
Value of Info	4 min	11 min	-	-	-

5.2c. Route Choice = f (Cognitive knowledge, Dummy Var., Information)

Purpose	Commute Trips	Event	Shopping	Recreation	Visit
Aesthetics	-.05	.56	-.72*	2.8***	1.48***
Commercial	-2.7**	-.27	1.55***	.21	-.35
Efficiency	.88***	.46***	.09	.02	.50***
Easiness	.06	.11	.00	.20	.34**
Pleasure	.16	.15	.15	.31**	-.01
Unfamiliarity	-.28***	-.19***	-.02	-.03	-.17**
Information	.13	.13	.08	-.01	-.01
Psudo-R^2	.30	.15	.09	.36	.20

*, **, ***: Statistically significant at levels 0.1, 0.05, 0.01 respectively

Table 5.3. Results: ordinary linear regression

Standardized Route Score = f (Cognitive knowledge, Dummies var., Information)

Purpose	Work	Home	Shopping	Recreation	Event	Visit
Aesthetics	.31***	.37**	-.27**	.61***	-.38	.06
Commercial	.05	.04	.49***	.46***	.71**	.33
Efficient	.10***	.08***	.03	.00	.18**	.18***
Easiness	.10***	.10***	.04	.01	.01	.06
Pleasure	.18***	.18***	.15***	.23***	.31***	.41***
Unfamiliarity	-.08***	-.06***	-.01	-.02	-.13***	-.15***
Information	.10*	.10	.02	.04	.07	.24
Constant	-1.64***	-1.71***	-1.06***	-1.32***	2.33***	1.81***
R^2	.43	.41	.16	.46	.13	.24

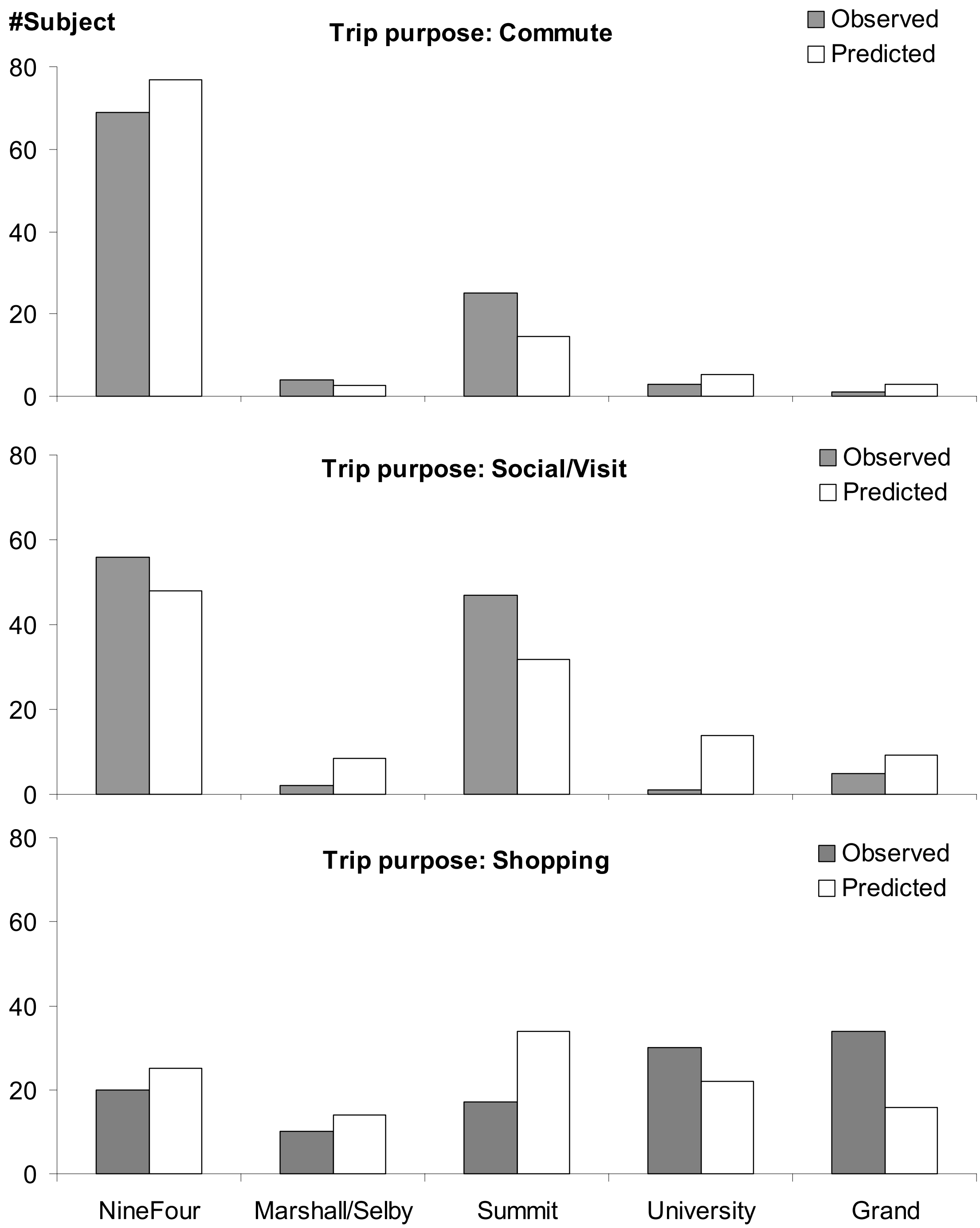
*, **, ***: Statistically significant at levels 0.1, 0.05, 0.01 respectively

The presence of pre-trip information for a route makes a route more attractive, as demonstrated by positive signs of the variable "information" in all models. A brief discussion of this variable is worthwhile. "Information" is a dummy variable which is 1 if a subject rated the accuracy of the information >5 on a 1~7 scale, and 0 otherwise. Another variable, "Information presence", has also been examined, which is 1 as long as traveler information is provided before a trip and 0 otherwise. However, "Information presence" is not statistically significant in all models, fails to pass specification *F* test, and therefore is dropped from the final models. "Information" (or more precisely "accurate information") is statically significant for commute and event trips in Tables 5.1 and 5.2, which is intuitive. It is not significant for trips with other purposes. These results also confirm findings from some previous studies that the quality and accuracy of traveler information is crucial to the success of ATIS.

By comparing overall model explanatory power among Tables 5.1a, 5.1b, and 5.1c (likelihood ratio), we can find that cognitive route knowledge (Table 5.1c) in all cases explains route-choice behavior significantly better than perceived route attributes (Table 5.1b), which explain route choice significantly better than observed route attributes (Table 5.1a). This suggests that there maybe a structure in the route perception and cognition process as illustrated in Figure 4.1. Most choice models applied to study human spatial behavior tend to relate observed attributes directly to the final choice, ignoring the perception and cognition process. Our findings suggest that it should be worthwhile to model route perception and cognition processes explicitly, which calls for corresponding development in spatial choice theory, a promising future research direction.

Finally, the reported and the predicted route choices based on the multinomial logit models are compared in Figure 5.1, which demonstrates the overall predictive accuracy of the logit models. Most participants choose I-94 for commute trips, while for other trip purposes the four arterial streets are also used by a significant percent of subjects. Although I-94 is clearly the most efficient of all alternatives based on the GPS data, drivers, by choosing the arterials, trade efficiency for other features such as aesthetics (Summit) and level of commercial development (Grand and University).

Figure 5.1. Reported and predicted route choices for different trip purposes.



5.2 Value of Information by Trip Purposes, Routes, and Level of Congestion

The elasticity between the presence of accurate information and travel time in the route choice models is a measure of the value of information in terms of equivalent time savings. The value of information clearly depends on a number of factors. Let us first examine the impacts of trip purpose. Results suggest that the provision of information is especially valuable for commute and event trips. Based on the rank-ordered logit models (Tables 5.1a and 5.1b), the value of pre-trip information for commute trips is about equivalent to a 5-minute time savings. Information is more valuable for event trips (9 minutes) on a per-trip basis. It is possible that pre-trip travel-time information can more significantly reduce schedule delay or travel-time delay cost for event trips than for other trips because event trips are typically characterized by time pressure and uncertainty (unfamiliarity with the routes to event destinations, parking waiting time etc.). On a separate note, value of time itself may vary with trip purposes. For instance, saving 5 minutes for commute trips is different from saving 5 minutes for recreational trips. Since the variation of value of time has not been adequately studied in previous research, value of time is assumed to be $10/hour for all trips. Multinomial logit models (Tables 5.2a and 5.2b) provide similar value-of-information results with higher variation (1 actual minute and 4 perceived minutes for commute trips, 1 actual minute and 11 perceived minutes for event trips). If one converts the time savings into dollars, the monetary value of information ranges form $0.15 to $1 per trip. Travelers do not seem to be willing to pay for travel-time information for shopping and recreational trips.

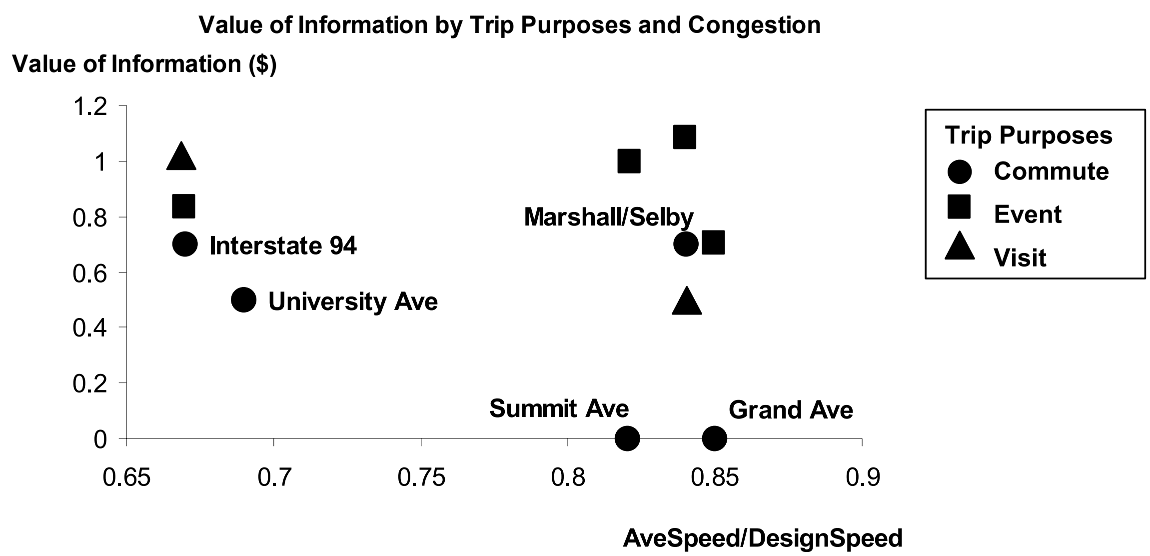
It has also been hypothesized that the perceived value of information would be higher when the level of congestion on a route is higher. At least, the actual benefit of traveler information is higher in a moderately congested commute corridor than in an uncongested corridor (Levinson 2003). Kanafani and Al-Deek (1991) argued that the benefits of ATIS are negatively related to the speed of arterial streets. By using the standardized route score as the dependent variable, we are able to differentiate value of information for the five selected routes (this is not possible in logit models with choice or rank as the dependent variable). Results from these regression models allow us to plot value of information against various route attributes. The ratio of average travel speed of all subjects to the design speed (defined as the 95^{th} percentile speed) is used in Figure 5.2 as an indicator of congestion. There is some evidence that information is more valuable on routes with higher congestion, but there are exceptions (event trips in Figure 5.2a). Imagine that a traveler is planning a trip. What is valuable to him or her is the travel-time information on both the planned route and alternative route. By the design of our field experiment, results in Figure 5.2a only reflect the value of travel-time information for the planned route. Future studies should design more sophisticated experiments with real driving tasks (e.g. actual home-to-work trips) and various information provision strategies. In terms of the monetary value of information, the regression models generate results similar to logit choice models. There is variation for different trip purposes, but travelers would pay no more than $1 for pre-trip travel-time information.

Wolinetz *et al.* (2001) investigated travelers' willingness to pay for information in the 1998 Broad Area survey. In their study, survey participants were asked to report their willingness to pay for travel-time information on usual and alternative routes, and alternative route planner. They found that on average travelers are willing to pay $0.74 on a per-call basis, and $3.84 per month for such information. By surveying TravInfo callers, Khattak *et al.* (2003) found that travelers' willingness to pay is positively related to customization of information, trip characteristics, and personal attributes. Although our results suggest that trip purpose is a very important factor, personal attributes, such as age, gender, and income, are not significant in our regression model.

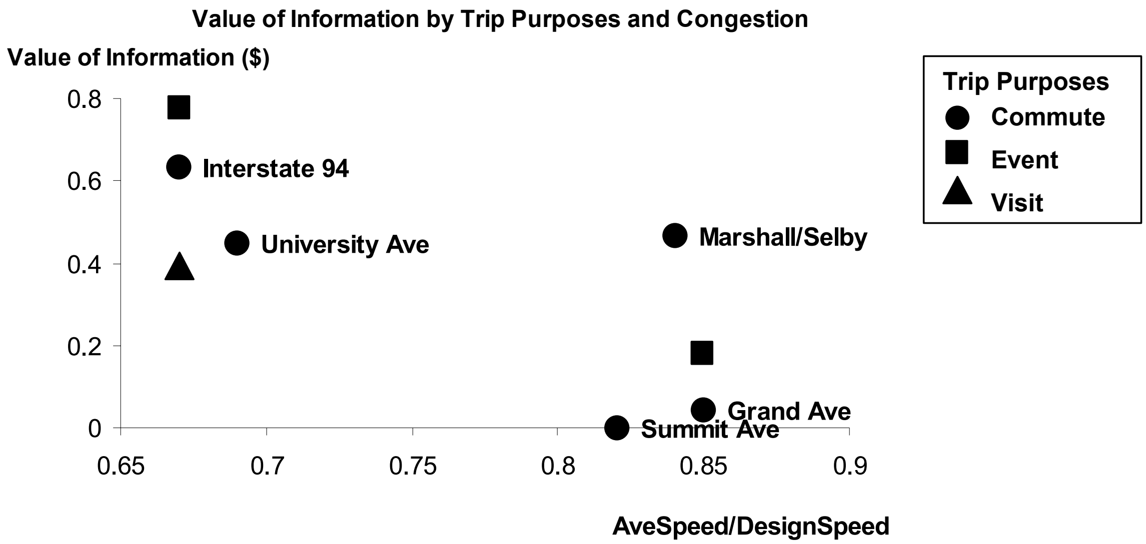
Several previous studies discuss the important of providing customized information to travelers according to their Origins and Destinations (OD), travel patterns, familiarity with the corridor, and individual characteristics (Kanafani & Al-Deek, 1991; Khattak *et al.*, 1993). It should be noted that the pre-trip travel-time information provided in the field experiment is customized to the OD pair, as there is only one OD pair in the experiment. The value of this type of information should be higher than more general traveler information, such as expected delay time on a specific route segment displayed on a variable message sign. Adler and Blue (1998) presented an interesting method for providing travelers with more personalized planning assistance based on artificial intelligence techniques.

Figure 5.2. Value of traveler information by route, trip purpose, and level of congestion

5.2a. Model: (top) Standardized route score = f (Observed road attributes, information)



5.2b. Model: (bottom) Standardized route score = f (Perceived road attributes, information)



Note: Values of information are computed based on $10/hr value of time.

5.3 Determinants of Information Usage and Public Acceptance of ATIS

Table 5.4 summarizes estimation results of information usage models developed in Section 4.2. The following factors positively affect the usage of traveler information: information accuracy, positive attitude toward information services, commute time, household vehicle ownership, and ownership of PCs and PDAs. The elderly population (>55) tends to use traveler information less often than others.

Table 5.4. Information usage

Dependent var. Independent var.	Frequency of using info. Scale 1 ~ 6 (most often) Ordinary regression	Information usage 1: often; 0: not often Binary logit
Accuracy of info (1~7 scale)	.27	3.42*
Positive attitude (1~7 scale)	.58**	3.32**
Commute time (min)	.03***	.38*
Num. Of Household vehicles	-.16	8.00*
Age (0 if >55, 1 otherwise)	-1.35*	-12.70**
Num. of PCs and PDAs	.81*	2.72
Constant	-2.92*	-61**
R^2 or Pseudo R^2	.39	.77
Sample size	43[1]	43

[1]: Only subjects provided with pre-trip information are included.

It has already been discussed in Section 5.1 that the accuracy of information is important. When the traveler information is perceived as inaccurate, there may not be any demand for such information services at all. Bad information, even occasional, could hurt the credibility of the service and create uncertainty in the quality of information itself.

CHAPTER 6
CONCLUSIONS

The success of ATIS depends on travelers' responses to the information, which are contingent on a number of properties of the information itself: quality, accuracy, usefulness, timeliness, user customization, cost, and the manner in which information is provided. Findings in the study suggest that travelers are willing to pay for traveler information, although the perceived value of information varies by trip purposes and route attributes. In most cases, drivers are willing to pay no more than $1/trip for pre-trip travel-time information. This conclusion is drawn from the field experience stated preference surveys (FESP), regression models, and discrete choice models developed in this research.

However, the task of understanding drivers' responses to information is challenging. Most studies using traditional route equilibrium assignment models tend to make assumptions about the role of information in reducing or eliminating perception errors. Given the various types of traveler information, various means of providing information, and the various preferences of drivers, theoretical studies based on static and even dynamic assignment models may have limited value in guiding the design and evaluation of ATIS. Survey techniques have been used to explore likely user responses and willingness to pay for ATIS. Field experiments, in which the behavior of travelers driving in real networks and performing real travel tasks with and without information services is monitored, seem to be a promising future research direction. The experiment of this study provides several lessons for the design of similar and more comprehensive ATIS-related experiments. First, technologies such GPS vehicle positioning systems are valuable, and provide accurate measures of routes traveled by the subjects. Second, combining GPS data with pre- and after-experiment surveys seem to be a promising experiment design methodology. In the survey, subjects can report their perceived route attributes, perceived accuracy of information and other important information. However, the survey must be carefully designed since subjects may confuse the experiment context with their daily routines. For instance, in our experiment, some subjects rated the importance of information for commute trips based on their routine daily commute trips, while some others might have given scores based on the four trips they drove during the experiment. Pre-tests for both the field experiment and survey questionnaire are necessary. Techniques for combing data from stated and revealed preference surveys have been developed and applied for value-of-time studies (Louviere & Hensher 2001). They could also be used to design future experiments valuing ATIS.

Another research need is the development of behavioral theories explaining how information provided by ATIS affects travelers' spatial perception, cognition, and decision-making process in a complex, dynamic, and uncertain transportation network. The theory should be able to generate testable hypotheses for empirical studies using survey techniques or field experiments.

The net social benefits of ATIS come from several sources: user benefits which is the difference between their willingness to pay and the cost of providing the information, benefits for users not using traveler information, other social benefits resulting from reduced levels of congestion (pollution emissions and fuel consumption). A rigorous economic appraisal of ATIS should be sought for operational traveler information systems. Understanding willingness-to-pay is only the first step.

Finally, it is also evident from the analysis that a number of factors affect route-choice behavior, and travel time is just one of them. However typically in discrete route choice and equilibrium route assignment models, the main independent variable that differentiates a driver's choice of route is travel time. This is primarily because other information about the quality of the trip or the valuation of the components of travel time (e.g. delay, stopped time, aesthetics) has been unavailable. The research trend in travel demand forecasting of moving toward disaggregate- and even individual-level models calls for better understanding of route choice at the microscopic level. Future studies should seek to incorporate more route attributes in route-choice models and develop spatial behavioral theories that can be applied to study route choice.

REFERENCES

Abdel-Aty, M.A., Kitamura, R., and Jovanis, P.P. (1997). Using stated preference data for studying the effect of advanced traffic information on drivers' route choice. *Transportation Research 5C*: 39-50.

Adler, J.L., and Blue, V.J. (1998). Toward the design of intelligent traveler information systems. *Transportation Research 6C*: 157-172.

Adler, J. L., Blue, V.J., and Wu, T.L. (1999). Assessing network and driver benefits from bi-objective In-vehicle route guidance. Presented in the 78th TRB Annual Meeting, TRB, 1999.

Al-Deek, H., and Kanafani, A. (1993). Modeling the benefits of advanced traveler information systems in corridors with incidents. *Transportation Research 1C*: 303-324.

Al-Deek, H.M., Ishak, S.S., and Radwan, A.E. (1998). Impact of traffic diversion with ATIS on travelers' safety. *Computers Ind. Engng. 34(2)*: 547-558.

Arentze, T., and Timmermans, H. (2000). *ALBATROSS: a learning-based transportation oriented simulation system*. EIRSS, Eindhoven

Barbaresso, J., and Grubba, J. (1993). Overview of the FASTTRAC IVHS program. Proceedings of IVHS America 1993 Annual Meeting: 630-637.

Bates, J. (1987). Measuring travel-time values with a discrete choice model: A note. *Economic Journal 97*: 493-498.

Behnke, R. (1992). California Smart Traveler System. USDOT Report No. DOT-T-92-16, Washington, D.C.

Ben-Akiva, M., Bergman, M.J., Daly, A.J., and Ramaswamy, R. (1984). Modeling inter-urban route choice behavior. In Volmuller, J., and Hamerslag, R., eds., *Proceedings of the Ninth International Symposium on Transportation and Traffic Theory*. VNU Science Press: The Netherlands.

Ben-Akiva, M., and Lerman, S.R. (1985). *Discrete choice analysis: Theory and application to travel demand*. The MIT Press: Cambridge, MA.

Ben-Akiva, M., De Palma, A., and Kaysi, I. (1991). Dynamic network models and driver information systems. *Transportation Research 25A*: 251-266.

Benshoof, J.A. (1970). Characteristics of drivers' route selection behavior. *Traffic Engineering and Control 11(12)*: 604-609.

Bovy, P.H.L., and Stern, E. (1990). *Route choice: Wayfinding in transport networks*. Kluwer Academic Publishers: The Netherlands.

Bhat, C.R., Schofer, J.L., Koppelman, F.S., and Bautch, R.C. (1993). Driver recruitability for advanced traveler information system experiments. *Transportation Research 4C*: 265-274.

Chang, G.L., and Junchaya, T. (1995). A dynamic route assignment model for guided and unguided vehicles with a massively parallel computing architecture. *Mathematical and Computer Modelling 22*: 377-395.

Deakin, A.K. (1997). Factoring motorists' responses to the 1994 Northridge Earthquake. *Computer, Environment, and Urban Systems 21*: 335-357.

Emmerink, R. H. M., Axhausen, K.W. and P. Rietveld. (1995). Effects of Information in road transport networks with recurrent congestion. *Transportation* 22: 21-53.

Emmerink, R.H.M., Verhoef, E.T., Nijkamp, P., and Rietveld, P. (1996). Information provision in road transport with elastic demand. *Journal of Transport Economics and Policy* 30(2):117-136.
Gilroy, R., Puentes, R., and Schuman, R. eds. (1998). *Choosing the Route to Traveler Information Systems Deployment:Decision Factors for Creating Public-Private Business Plans*. Published by ITS America.
Golledge, R.G. (1996). Geographical theories. *International Social Science Journal* 150: 461-476.
Golledge, R.G., and Stimson, R.J. (1997). *Spatial behavior: A geographic perspective*. The Guilford Press: New York.
Hall, R.W. (1993). Non-recurrent congestion: How big is the problem? Are travelers information systems the solution? *Transportation Research 1C*: 89-103.
Hall, R.W. (1996). Route choice and advanced traveler information systems on a capacitated and dynamic network. *Transportation Research 4C*: 289-306.
Hensher, D.A., and Goodwin, P.B. (1978). The transport determinants of travel choices: An overview. In Hensher, D.A. and Dalvi, M.Q. (eds.), *The determinants of travel choices*, Farnborough, England, Teakfield Saxon House Studies.
Hensher, D.A. (1975). The value of commuter travel-time savings: Empirical estimationusing an alternative valuation model. *Journal of Transport Economics and Policy 10(2)*: 167-176.
Hensher, D.A. (2001). Measurement of the valuation of travel-time savings. *Journal of Transport Economics and Policy 35(1)*: 71-98.
Hensher, D.A., and Goodwin, P.B. (2004). Implementation of values of time savings: the extended set of considerations in a tollroad context. *Transport Policy 11(2)*: 171-181.
Inman, V.W., and Peters, J.I. (1996). *TravTek global evaluation study*. FHWA-RD-96-031, Washington, DC.
Jara-Díaz, S. (1990). Consumer's surplus and the value of travel-time savings. *Transportation Research 24B*: 73-77.
Jara-Díaz, S. (2000). Allocation and valuation of travel-time savings. In Hensher, D.A., and Button, K.J. (eds.), *Handbook of transport modeling Volume 1* (pp. 303-319), Elsevier Science: Oxford, UK.
Jha, M., Madanat, S., and Peeta, S. (1998). Perception updating and day-to-day travel choice dynamics in traffic networks with information provision. *Transportation Research 6C*: 189-212.
Kanafani, A., and Al-Deek, H. (1991). A simple model for route guidance benefits. *Transportation Research 25B*: 191–201.
Khattak, A.J., Schofer, J.L., and Koppelman, F.S. (1993). Commuters' enroute diversion and return decisions: Analysis and implications for advanced travelers information systems. *Transportation Research 27A*: 101-111.
Khattak, A.J., Yim, Y., and Stalker, L. (2003). Willingness to pay for travel information. *Transportation Research 11C*: 137-159.
Khattak, A.J., Targa, F., and Yim, Y. (2004). Advanced traveler information systems: Relationship to traveler behavior. In Gillen, D., and Levinson, D. (eds.), *Assessing the benefits and costs of ITS*. Kluwer Academic Publishers, MA.

Koop, G., and Poirier, D.J. (1994). Rank-ordered logit models: An empirical analysis of Ontario voter preferences. *Journal of Applied Econometrics* 9(4): 369-88.
Koutsopoulos, H.N., and Lotan, T., (1990). Motorist information systems and recurrent traffic congestion: sensitivity analysis of expected results. *Transportation Research Record* 1281, 145–158.
Koutsopoulos, H.N., and Xu, H. (1993). An information discounting routing strategy for advanced traveler information systems. *Transportation Research 1C*: 249-264.
Levinson, D.M. (2002). The economics of traveler information from probes. *Public Works Management and Policy* 6(4): 241-250.
Levinson, D.M. (2003). The value of advanced traveler information systems for route choice. *Transportation Research 11C*: 75–87.
Levinson, D.M., Harder, K.A., Bloomfield, J.R. and Winiarczyk, K. (2004). Weighting Waiting: Evaluating Perception of In-Vehicle Travel Time under Moving and Stopped Conditions. *Transportation Research Record: Journal of the Transportation Research Board*, #1898, 61-68.
Ligas, J., Bowcott, S., Boyce, D., Nelson, P., Schofer, J., Koppelman, F., and Kirson, A. (1993). An update on ADVANCE. *Proceedings of IVHS America 1993 Annual Meeting*: 621-625.
Lo, H., and Szeto, W.Y. (2002). A methodology for sustainable traveler information services. *Transportation Research 36B*: 113–130.
Lo, H.K., and Szeto, W.Y. (2004). Modeling advanced traveler information services: Static versus dynamic paradigms. *Transportation Research 38B*: 495–515.
Louviere, J.J., and Hensher, D.A. (2001). Combining Preference Data, In Hensher, D.A. (ed.), *The leading edge of travel behaviour research*, Pergamon Press: Oxford.
Louviere, J. and Street, D. (2000). Stated-Preference Methods. In: Hensher, D.A. and Button, K.J. *Handbook of Transport Modelling*. New York, N.Y.: Elsevier Science Ltd, pp132-143.
Maher, M.J., and Hughes, P.C. (1995). Estimation of the potential benefits from an ATT system using a multiple user class stochastic user equilibrium assignment model. In Stephanedes Y.J., Filippi, F., (eds.), *Applications of Advanced Technologies in Transportation Engineering*, Proceedings of the 4th International Conference, Capri, Italy, June 27-30, 1995, pp. 700-704.
Mahmassani, H., and Chen, P. (1991). Comparative assessment of origin-based and en-route real-time information under alternative user behavior rules. *Transportation Research Record* 1306: 69-81.
Mahmassani, H., and Jayakrishnan, R. (1991). System performance and user response under real-time information in a congested traffic corridor. *Transportation Research 25A*: 293-307.
Mahmassani, H.S., Huynha, N.N., Srinivasan, K.K., and Kraanc, M. (2003). Tripmaker choice behavior for shopping trips under real-time information: model formulation and results of stated-preference Internet-based interactive experiments. *Journal of Retailing and Consumer Services 10*: 311-321.
Manski, C. (1977). The structure of random utility models. *Theory and Decision 8* 229-254.
McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In Zarembka, P. (ed.) *Frontiers in Econometrics*. Academic Press: New York.

Ng, L., Barfield, W., and Mannering, F. (1995). A survey-based methodology to determine information requirements for advanced traveler information systems. *Transportation Research 3C*: 113-127.

Pattanamekar P., Park, D., Rilett, L.R., Lee, J., and Lee, C. (2003). Dynamic and stochastic shortest path in transportation networks with two components of travel-time uncertainty. *Transportation Research 11C*: 331–354.

Peckmann, M. (1996). STORM Stuttgart transport operation by regional management-results on the field: Trials and assessment. In the 3rd Annual World Congress on Intelligent Transport Systems: Intelligent Transportation: Realizing the Future, OCT 14-18 1996, Orange County Convention Center, Orlando, Florida, ITS America.

Perez, W.A., Fleischman, R.N., Golembiewski, G., and Dennard, D. (1993). TravTek field study results to date. *Proceedings of IVHS America 1993 Annual Meeting*: 667-673.

Schiller, J., and Voisard, A. eds. (2004). Location-based services. Elsevier Science.

Slovic, P., Fischoff, B., and Lichtenstein, L. (1977). Behavioral decision theory. *Ann. Rev. Psychology*.

Small, K.A., Noland, R.B., and Koskenoja, P. (1995). Socio-economic attributes and impacts of travel reliability: A stated preference approach. PATH Report, MOU-117.

Small, K.A., Noland, R.B., Chu, X., and Lewis, D. (1999). Variation of travel-time savings and predictability in congested conditions for highway user-cost estimation. NCHRP Report 431.

Srinivasan, K.K., and Mahmassani, H.S. (2003). Analyzing heterogeneity and unobserved structural effects in route-switching behavior under ATIS: A dynamic kernel logit formulation. *Transportation Research 37B*: 793–814.

Stern, E., and Leiser, D. (1988). Levels of spatial knowledge and urban travel modeling. *Geographical Analysis 20(2)*: 140-155.

Stern, E., and Leiser, d. (1989). A cognitive utility model of urban route choice. Report for the Israel National Academy of Science, Beer Sheva, Israel.

Svenson, O. (1979). Process descriptions of decision-making. *Org. Behavior Human Performance 23*: 86-112.

Tilahun, N., Levinson, D. and Krizek, K. (2005) Trails, Lanes, or Traffic: The Value of Different Bicycle Facilities Using an Adaptive Stated Preference Survey. *Under review.*

Ulrich, S.R. (1974). Scenery and the shopping trip: the roadside environment as a factor in route choice. *Michigan Geographical Publication 12*, University of Michigan, Ann Arbor, MI.

Van Vuren, T., Van Vliet, D., and Smith, M.J. (1989). Combined equilibrium in a network with partial route guidance. In: Yagar, S., Rowe, S.E. (Eds.), Traffic Control Methods. Engineering Foundation, New York, pp. 375–387.

Vaziri, M., and Lam, T.N. (1983). Perceived factors affecting driver route decisions. *Journal of Transportation Engineering 109(2)*: 297-311.

Wachs, M. (1967). Relationships between drivers' attitudes toward alternate routes and driver and route characteristics. *Highway Research Record 197*: 70-87.

Wahle, J., Bazzan, A.L.C., Klügl, F., and Schreckenberg, M. (2002). The impact of real-time information in a two-route scenario using agent-based simulation. *Transportation Research 10C*: 399–417

Wolinetz, L., Khattak, A., and Yim, Y. (2001). When will some individuals pay for traveler information and when it can be free? Analysis of a Bay Area Travel Survey. *Transportation Research Record 1759*.

Wunderlich, K.E. (1995). Congestion and route guidance benefits assessment. The MITRE Corporation, letter ITS-L-131, October 1995.

Wunderlich, K. E. (1996). An assessment of pre-trip and en route ATIS benefits in a simulated regional urban network. In *The 3rd World Congress on Intelligent Transport Systems, Intelligent Transportation: Realizing the Future*, Orlando, Florida, 1996.

Wunderlich, K.E. (1998). A simulation-based assessment of route guidance benefits under variable network congestion conditions. *Mathematical and Computer Modelling 27*: 87-101.

Yang, H. (1998). Multiple equilibrium behaviors and advanced traveler information systems with endogenous market penetration. *Transportation Research 32B*: 205–218.

Yang, H., and Meng, Q. (2001). Modeling user adoption of advanced traveler information systems: Dynamic evolution and stationary equilibrium. *Transportation Research 35A*: 895-912

Yin, Y., and Yang, H. (2003). Simultaneous determination of the equilibrium market penetration and compliance rate of advanced traveler information systems. *Transportation Research 37A*: 165–181.

APPENDIX A
POST-ROUTE SURVEYS

Post-Route Questions For Participants Who Received Travel-Time Information

In this study we are interested in driver preference for commuter routes. We selected routes between the University of Minnesota and the Cathedral of St. Paul because they are easily identifiable destinations.
For Questions 1 - 4 please think of the route you just drove as part of your commute to or from work and circle a number from 1 to 7 that best reflects your answer to the question.

1. Please rate the route you just drove with regard to its efficiency.

Very inefficient 1 2 3 4 5 6 7 Very efficient

2. Please rate the route you just drove with regard to how easy it was to drive.

Very difficult 1 2 3 4 5 6 7 Very easy

3. Please rate the route you just drove with regard to how pleasant it seemed to be.

Very unpleasant 1 2 3 4 5 6 7 Very pleasant

4. How accurate was the travel information you were given at the beginning of the drive?

Not at all accurate 1 2 3 4 5 6 7 Very accurate

5. If you were given travel information as accurate as the travel information you received at the beginning of this drive, please rate how useful you think the information would be to you on a daily basis?

Not at all useful 1 2 3 4 5 6 7 Very useful

6. How often do you drive this particular route? (Place a check in front of your answer.)

__ everyday __ several times a month __ once or twice a year

__ several times a week __ once a month __ never

__ once a week

7. Did you hear traffic reports on the radio during this trip?

__ yes __ no

For Questions 8-16 please think of the route you just drove as part of your commute to or from work and circle a number from 1 to 7 that best reflects your answer to the question.

8. How would you rate driving a route very much like this **to work** in the morning, assuming **no stops** for shopping, daycare and the like?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

9. How would you rate driving a route very much like this **to work** in the morning, assuming that you make **typical stops** for shopping, daycare and the like along the way?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

10. How would you rate driving a route very much like this **home from work**, assuming **no stops** for shopping, daycare and the like?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

11. How would you rate driving a route very much like this **home from work**, assuming that you make **typical stops** for shopping, daycare and the like along the way?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

How would you rate driving a route very much like this for…

12. shopping? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

13. going to the theater or a movie? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

14. visiting family/friends? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

15. going to a park? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

16. a Sunday drive? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

17. Did anything unusual happen when you drove this route?

__ yes __ no If yes, please explain____________________________________

Post-Route Questions For Participants Who DID NOT Receive Travel-Time Information

In this study we are interested in driver preference for commuter routes. We selected routes between the University of Minnesota and the Cathedral of St. Paul because they are easily identifiable destinations.

For Questions 1 - 4 please think of the route you just drove as part of your commute to or from work and circle a number from 1 to 7 that best reflects your answer to the question.

1. Please rate the route you just drove with regard to its efficiency.

Very inefficient 1 2 3 4 5 6 7 Very efficient

2. Please rate the route you just drove with regard to how easy it was to drive.

Very difficult 1 2 3 4 5 6 7 Very easy

3. Please rate the route you just drove with regard to how pleasant it seemed to be.

Very unpleasant 1 2 3 4 5 6 7 Very pleasant

4. How often do you drive this particular route? (Place a check in front of your answer.)

__ everyday
__ several times a week
__ once a week
__ several times a month
__ once a month
__ once or twice a year
__ never

5. Did you hear traffic reports on the radio during this trip?

__ yes __ no

For Questions 6-14 please think of the route you just drove as part of your commute to or from work and circle a number from 1 to 7 that best reflects your answer to the question.

6. How would you rate driving a route very much like this **to work** in the morning, assuming **no stops** for shopping, daycare and the like?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

7. How would you rate driving a route very much like this **to work** in the morning, assuming that you make **typical stops** for shopping, daycare and the like along the way?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

8. How would you rate driving a route very much like this **home from work**, assuming **no stops** for shopping, daycare and the like?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

9. How would you rate driving a route very much like this **home from work**, assuming that you make **typical stops** for shopping, daycare and the like along the way?

Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

How would you rate driving a route very much like this for…

10. shopping? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

11. going to the theater or a movie? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

12. visiting family/friends? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

13. going to a park? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

14. a Sunday drive? Very Unsatisfying 1 2 3 4 5 6 7 Very Satisfying

15. Did anything unusual happen when you drove this route?

__ yes __ no

If yes, please explain____