# Transit Pre-Trip Information Systems: An Experimental Analysis of Information Acquisition and Its Impacts on Mode Use

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**Abstract**
In-laboratory interviews were conducted with approximately 50 subjects who used a PC-based transit pre-trip information system prototype. The objectives of the study were: (i) to determine which types of information are more important to the user, (ii) to examine whether an exposure to the information system alters the users' perception of and attitudes toward public transit, and (iii) to assess user receptiveness of such an information system.

## 1. Introduction

Advanced pre-trip transit information systems are envisioned as devices that provide their users with information on transit service such as routes, schedules, fares, and opportunities around transit stops. They are envisaged also to offer real-time information such as the anticipated arrival time of the next bus or train, and individualized information such as the route to take or the expected travel time of the trip the user intends to make. Such information is expected to improve the level of service for transit users and increase the patronage of the transit system by letting potential users be aware of its service characteristics. Furthermore, providing information may possibly change non-users' attitudes toward public transit, which may entice more travelers to public transit.

This study is an attempt to aid in thedevelopment of effective transit information systems and to assess their potential usefulness. The objectives of the study are:

1. to determine which types of information are more important to the user,
2. to examine whether an exposure to the information system alters the users' perception of transit attributes and their attitudes toward public transit, and
3. to assess user receptiveness of such an information system.

The second objective is concerned with the potential roles transit information systems may play beyond delivering information.

To achieve these objectives, in-laboratory experiments were conducted with approximately 50 subjects from the Sacramento, California, metropolitan area. In each experimental session the subject used a PC-based, menu-driven information system prototype, which had been developed as part of this study. In addition, sets of questions were asked to collect information about subjects' demographic and socio-economic attributes, commute characteristics, and their valuations of the information system prototype.

The prototype was equipped with the ability to record automatically all the input commands made by the subject and to measure the duration of each information display. This facilitated the examination of the frequency and duration with which each type of information was accessed. Relative importance of different types of information is inferred based on the data thus collected.

Achieving the second objective involved measurement difficulties because the impact of the use of an information system on the subjects' attitudes and perception can be very subtle, and directly questioning subjects whether and how the experience of its use has affected them may only lead to responses with affirmation bias. The approach taken was to ask each subject comparable questions before and after the use of the prototype, measure differences in responses, and infer the impact of using the prototype. The experiment included the following: (a) two sets of matched and randomly ordered attitudinal questions, and (b) two sets of stated-preference (SP) auto-versus-transit mode choice questions. Statistical analyses were performed to the resulting data sets to discern changes in attitudes and preferences that are attributable to the use of the prototype.

In this paper, the prototype used in the experiments is described in Section 2, then the design of the experiments is described in detail in Section 3. The results of the analysis of the experimental data are presented in Section 4. Sections 5 and 6 present the analyses of the before-and-after attitudinal measurements and before-and-after SP data, respectively. Responses to the questions asked at the end of the experiment about such an information system are analyzed in Section 7. Section

8 offers conclusions and recommendations. No literature review is included in this paper; see [1] and [2] for comprehensive reviews of studies in the areas of advanced traveler information systems.

## 2. Prototype Development

The prototype was developed for the City of Davis, California. Its small size (population of about 55,000), well developed bus networks, and geographical proximity to the Institute of Transportation Studies (ITS) at Davis, all contributed to the desirability of the study area for prototype development.

*Unitrans Bus System:* Unitrans, which is operated by the Assembly of Students of University of California, Davis (ASUCD), provides the intra-city bus service in Davis. Its bus routes comprise most of the bus networks in Davis, which cover better parts of the city. Bus stops are located on average at every other block along the route. Currently there are eleven bus routes that converge at a few terminals located on the University of California, Davis (UCD) campus. Bus schedules are coordinated with class schedules, providing convenient and reliable service to the campus community. During class periods the service runs from 7:00 A.M. to 11:30 P.M., Monday through Thursday, and from 7:00 A.M. to 6:30 P.M. on Fridays. A single ride costs 50 cents. All registered UCD undergraduate students and senior citizens (60 years old or over) with a pass obtained from the Davis Senior Center, can ride Unitrans bus free.

*Prototype:* The pre-trip transitinformation system developed in this study is an interactive PC program on the Windows platform. A set of menus, each consisting of a group of mouse- or keyboard-operated buttons for different pieces of information, is displayed on screen to provide access to the range of information available from the prototype data base. Its current capabilities are limited to the storage of static information and the provision of systematic access to it. Abilities to identify locations, search for optimum routes, or suggest travel options, are yet to be developed.

In the background, C-language modules generate a road network map, bus route maps, and maps showing bus stop locations, banks and other opportunities, landmarks, etc., for the study area. In the data base, the street network map for Davis is stored as a base map. This is overlaid with appropriate route maps. The route maps are then overlaid with bus stops and their names. The road network was initially extracted from TIGER line files and converted to the computer screen coordinate system of the prototype. The prototype therefore displays most local streets as well as all major freeways and arterials.

Other than maps, the data are stored and presented in the text, graphics and image (scanned pictures) format. Bus schedules, travel times, and other textual data are presented in the text format on screen. Photographs of selected public facilities, landmarks, and commercial establishments are stored as bit-map images and presented on screen upon request. The information available in the prototype is accessed using the following menus:

- *Bus Schedule:* Contains the time table for each bus route.
- *Travel Time:* Instructs the user how to use the schedule menu to compute travel times.
- *Frequency:* Displays bus departure frequencies by route and time of day.
- *Bus Terminals:* Presents digitized photographic images of the bus terminals with textual information.
- *About Unitrans:* Presents a summary description of the Unitrans system and services provided.
- *Fares and Passes:* Shows the fares to use Unitrans system for different types of users, and where to purchase passes and tickets.
- *Bus Stop Location:* Shows bus stops on the Davis road network map and bus route maps.
- *Route Map:* Used to select bus route maps.
- *Hours of Operation:* Displays Unitrans' operating hours in different parts of the year.
- *Service Types:* Displays types of services available from Unitrans.
- *Service Calendar:* Displays services available from Unitrans through the year in more detail on a calendar.
- *Bus Stops by Bus Route:* Shows the bus routes that serve each bus stop.

## 3. In-laboratory Experiment Design

The in-laboratory experiment sessions are described in this section. First the experimental design used for the selection of subjects is presented. Following this, the contents of the session are outlined, and the tasks assigned to each subject during the experiment are described in detail. The administration of the sessions and profiles of the subjects are also given.

*Experimental Design:* The population from which subjects were to be drawn for the experiments was defined as the group of full-time workers in the Sacramento metropolitan ~~area~~ who were 16 years old or over and who commuted regularly between 6:00 A.M. and 10:00 A.M. The following demographic blocking factors were used for the recruitment of subjects and to assign variants of the SP questions in a randomized block design: (1) age (up to 40 years old, over 40 years old); (2) sex (male, female); and (3) familiarity with transit service (use transit service, do not use). A complete factorial design called for $2^3 = 8$ replications, and with six observations per design cell, 48 subjects were required. This design allowed for the estimation of all main and interaction effects involving these three factors.

*Contents of the Experiment:* The following surveys and tasks were included in each experimental session (the questionnaires administered can be found in (31).

1. *Initial Survey:* A series of questions was administered to collect demographic and socio-economic attributes of the subject.
2. *Pre Attitudinal Survey:* A set of attitudinal questions was administered before subjects carried out two tasks using the prototype. These questions addressed subjects' attitudes towards different travel modes (driving alone, ridesharing, public transit), about their attributes (comfort, security, reliability), and attitudes about existing travel information. The order in which questions was asked were randomized to avoid sequencing bias.
3. *Pre SP Survey:* SP questions were developed to elicit responses regarding how likely a subject would be to use a transit alternative based on hypothetical characteristics of a choice set which involved transit and drive-alone alternatives.
4. *Way-Finding Experiments:* Subjects were then asked to perform a series of tasks utilizing the pre-trip transit information system prototype. They were asked to figure out how to make trips using the Unitrans system and determine scheduling details for the trip.
5. *Post SP Survey:* A set of SP questions similar to those in 3 were administered based on assignment from experimental design.
6. *Post Attitudinal Survey:* Another set of attitudinal questions that paralleled those asked in the pre survey was asked to each subject.
7. *End Questions:* A set of questions was asked to determine how the subject evaluated the information prototype with which he/she experimented.

The pre and post attitudinal and SP surveys were incorporated into the experiment with the intent of measuring possible changes in attitudes toward public transit that might be brought about by the use of the information system prototype.

*Way-Finding Tasks :* The main component of the in-laboratory experiment session comprised way-finding tasks in which subjects were asked to make hypothetical trips in Davis using the Unitrans bus system. An example task is described here exactly the way it was presented to the subject.

**TASK 1**

In this task, you are asked to make a hypothetical trip by transit. Assume that it is 10:00 A.M. and you are on the U.C. Davis campus as you are today and that you would like to go to the Lucky Shopping Plaza located at the corner of Anderson Road and Covell Blvd. in Davis, and that you would like to reach the Plaza by 11:00 A.M. To make this trip you will use the UNITRANS Transit system. All UNITRANS buses depart from campus either at the Silo or Shields Library on Hutchison Dr. or from the Memorial Union on Howard Way. To help you plan your trip, a Transit Information System is available for your use. Use this system to find a bus line which services the location you wish to go to at the required time of your trip.

**Requirements**

Starting Point: UC Davis Campus
Destination: Lucky Plaza, Anderson and Covell
Desired Arrival Time: 11:00 A.M.

**Results:**

When you have determined how you will make this trip, please provide the following information.

1. Bus Line Used: ___ (example, A, B, etc.)
2. Scheduled Departure Time: ____ (example, 9:50 A.M.)
3. Does this Bus leave from the Silo or Memorial Union Terminal? (check one)

   _ Silo
   _ Shields Library
   _ Memorial Union

4. Scheduled arrival time at destination Stop: ____

The subject performed a second task, similar to Task 1, during the experiment. The recruiting and interviews were staged in two waves around the 1994 Thanksgiving holiday.

*Profiles of the Subjects :* By the experimental design adopted, the 48 subjects who participated in the experiments split evenly between men and women, and between up to and over 40 years old. The mode of the household size distribution is two and the average household size is estimated to be 2.5. Nine subjects were from single-person households while 10 were from households with four or more members. All but one subject had at least one vehicle available to the household, and a half of the subjects had two vehicles available. The average number of vehicles per household is 1.69. A majority (85%) of the subjects had at least some college education, eight (17%) had college degrees, and 11 (23%) had graduate education. The income distribution has its mode in the $20,001 to $40,000 range and its median in the $40,001 to $60,000 range. A majority (39 or 81%) of the subjects commuted at least five days a week, and another five commuted four days a week. Driving alone is the commute travel mode most often used by the subjects. Because of the experimental design used to recruit subjects, transit users are over-represented in the sample. One half of the subjects (24) indicated that they had used public transit at least five times in last month in response to recruitment screening questions.

## 4. A Review of Experimental Results

The mean access frequency to the menus while performing the two tasks in the experimental session is 46.2; frequencies range from a minimum of 6 and a maximum of 208 and have a standard deviation of 41.3 and a coefficient of variation (variance-to-mean ratio) of 0.89. Apparently some subjects were able to obtain needed information quite efficiently while the tasks were quite burdensome for other subjects.

The menus are broadly grouped into four: (i) those giving general information about Unitrans, (ii) those pertaining to bus lines, schedules, stop locations, and other service attributes, (iii) those giving information about opportunities in Davis, and (iv) those that present the routes and schedules of the respective bus lines. An inspection of access frequencies indicated that those menus in the first and third categories were not frequently accessed. On the other hand, the menus for the list of bus schedules by route and for the list of bus route maps, were most frequently accessed. Route maps and schedules are evidently the most important information when planning transit trips to a specific destination by a specific time.

The mean total elapsed time to perform twotasks using the prototype is 1,188 seconds (or 19.8 min.), with a minimum of 146 sec. (2.43 min.), a maximum of 4,316 sec. (71.9 min.), a standard deviation of 948 sec, and a coefficient of variation of 0.798. The dwell time at a menu was recorded automatically as the time since the subject accessed the menu until the time when he/she exited from it. Unfortunately there were cases where subjects did not use the exit button but used the escape key or other methods to exit a menu. In this case the dwell time was not recorded. Consequently the above dwell time statistics under-represent the actual time spent by subjects on the prototype.

Despite this limitation, it is important to note that the mean elapsed time of 19.8 min. for two route-finding tasks (approximately 10 min. per task) does not seem much shorter, if not longer, than the time it would take to locate the origin and destination on a paper map and find a bus line to take. This is especially so in Davis, which is a small town with a simple street network and about a dozen bus lines. The result suggests that one should not anticipate that the user of a public transit information system would use it to find bus lines or to look up schedules. This process must be automated, i.e., the user inputs the origin (if applicable) and destination, and the time by which he/she wishes to arrive at the destination (or the time at which he/she can leave the origin); then the system offers a recommended bus line(s) and a departure time. One focus of the user interface development, then, should be on how to make it simpler for the user to either input origin-destination locations or to locate an opportunity which serves his/her needs.

## 5. Analysis of Before-and-After Attitudinal Measurements

Two matched sets of attitudinal questions were asked to subjects before and after they experimented with the information prototype. The questions were administered such that one half of the subjects received one of the two sets before the experiment, while the other half of the subjects received the other set before the experiment. After the experiment the subject received the other set of questions to which he/she had not exposed. Therefore each subject was exposed to all the questions, but was never asked the same question twice; while each question was asked both before and after the experiment, but to different halves of the subjects.

**Tablel**
Distribution of Responses to Attitudinal Questions
Before and After Using
**the Information System Prototype:**
Set I

*Q.1. Driving allows me freedom.*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 0 | 1 | 2 | 14 | 7 | 24 | 4.13 | 0.741 |
| A | 2 | 2 | 5 | 10 | 5 | 24 | 3.58 | 1.176 |
| $\Sigma$ | 2 | 3 | 7 | 24 | 12 | 48 | 3.85 | 1.010 |

$x^2$=4.00

*Q.2. I am not comfortable riding with strangers.*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 2 | 13 | 4 | 4 | 1 | 24 | 2.54 | 1.021 |
| A | 3 | 13 | 4 | 2 | 2 | 24 | 2.46 | 1.103 |
| $\Sigma$ | 5 | 26 | 8 | 6 | 3 | 48 | 2.50 | 1.052 |

$x^2$=0.09

*Q.3. Bus schedules are reliable*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 0 | 4 | 4 | 14 | 2 | 24 | 3.58 | 0.881 |
| A | 1 | 2 | 5 | 16 | 0 | 24 | 3.50 | 0.834 |
| $\Sigma$ | 1 | 6 | 9 | 30 | 2 | 48 | 3.54 | 0.849 |

$x^2$=0.00

*Q.4. Traveling by bus is pleasant.*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 3 | 11 | 8 | 1 | 24 | 3.21 | 0.884 |
| A | 2 | 3 | 7 | 12 | 0 | 24 | 3.21 | 0.977 |
| $\Sigma$ | 3 | 6 | 18 | 20 | 1 | 48 | 3.21 | 0.922 |

$x^2$=0.76

*Q.5. People tend to have false impression that using transit is not safe.*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 7 | 4 | 9 | 3 | 24 | 3.25 | 1.152 |
| A | 2 | 3 | 5 | 11 | 3 | 24 | 3.42 | 1.139 |
| $\Sigma$ | 3 | 10 | 9 | 20 | 6 | 48 | 3.33 | 1.136 |

$x^2$=0.34

*Q.6. Bus time tables help us plan a trip.*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 1 | 2 | 9 | 11 | 24 | 4.17 | 1.049 |
| A | 1 | 0 | 0 | 11 | 12 | 24 | 4.38 | 0.875 |
| $\Sigma$ | 2 | 1 | 2 | 20 | 23 | 48 | 4.27 | 0.962 |

$x^2$=0.08

*Q.7. Bus time tables are easy to understand.*

| | S.D. | D. | N. | A. | S.A | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 4 | 5 | 13 | 1 | 24 | 3.38 | 0.970 |
| A | 2 | 11 | 3 | 7 | 1 | 24 | 2.75 | 1.113 |
| $\Sigma$ | 3 | 15 | 8 | 20 | 2 | 48 | 3.06 | 1.080 |

$x^2$=2.96

**Tablel (Continued)**

*Q.8. A map showing bus routes is not that important.*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 13 | 11 | 0 | 0 | 0 | 24 | 1.46 | 0.509 |
| A | 9 | 14 | 0 | 1 | 0 | 24 | 1.71 | 0.690 |
| $\Sigma$ | 22 | 25 | 0 | 1 | 0 | 48 | 1.58 | 0.613 |

$x^2$=1.34

*Q.9. Where the next bus is running now is important to know*

| | S.D. | D. | N. | A. | S.A. | $\Sigma$ | $\hat{\mu}$ | $\hat{\sigma}$ |
|---|---|---|---|---|---|---|---|---|
| B | 1 | 0 | 0 | 10 | 13 | 24 | 4.42 | 0.881 |
| A | 1 | 1 | 0 | 16 | 6 | 24 | 4.04 | 0.908 |
| $\Sigma$ | 2 | 1 | 0 | 26 | 19 | 48 | 4.23 | 0.905 |

$x^2$=4.27

S.D.= Strongly Disagree; D.= Disagree
N.=Neutral; A.= Agree; S.A.= Strongly Agree
$\Sigma$ =Total; $\hat{\mu}$=Average; $\hat{\sigma}$=Standard Diviation
B= Before; A= After; $\Sigma$ =Total

Each set comprised a total of nine questions. In each question a statement was presented to the subject, who was asked to indicate how he/she would agree with the statement, on a five-point semantic scale from "Strongly Disagree" to "Strongly Agree." The statements were concerned with attitudes toward the automobile, public transit, and information for public transit. The objective of the analyses of this section is to assess whether the exposure to the pre-trip information system prototype had any impact on the attitudes the subjects had toward public transport.

Responses to the attitudinal questions in general have similar distributions on the semantic scale before and after the experimentation (Table 1 for results for one of the sets). Partly due to the small sample size, only a few of the tables exhibit statistically significant differences in the distribution. An inspection of the chi-square statistics and average response scores indicate that the response can be considered different before and after for the following questions:

"Driving allows me freedom";
"Bus time tables are easy to understand"; and
"Where the next bus is running now is important to know."

The difference is statistically significant at a 5% level for the first and third statement above, and at 10% for the second statement. No significant difference can be found for the rest of the statements. Notably responses show no significant difference for the statement, "Computer-based information systems are hard to use."

The before and after distributions for"Driving allows me freedom" indicate that the responses were more negative after the experiment. The distribution of responses to "Bus time tables are easy to understand" also leaned toward disagreement after the experiment. It can be said that actually using time tables to plan trips during the experiment caused this difference. On the other hand subjects are agreeing less with the statement "Where the next bus is running now is important to know." This may indicate that the subjects felt the information obtained from time tables is sufficient for trip planning, therefore knowing where the bus is running is not important. Overall, however, the differences found in the responses to the attitudinal questions are often not appreciable. The analysis of this section indicates that the impact of the use of the public transit pre-trip information system prototype upon attitudes toward public transit is small.

## 6. Analysis of Before-and-After SP Data

With the same purpose of determining whether using a pre-trip transit information affects the users' attitudes towards public transit, another two matched sets of questions were administered before and after the experiment with the prototype.

*Development of SP Structure* : The SP questions are structured in a "transit vs. drive alone" framework dimensioned by travel time and travel cost with travel time customized from each subject's own commute travel time. In the initial survey subjects were asked to indicate usual travel time from home to work (say, T). The following multiplier values were used in the SP question design:

Transit Multiplier (TM) = 0.6, 1.0, 1.4.
Drive Multiplier (DM) = 0.8, 1.0, 1.2.

Using these, the travel time was defined as

Transit Travel Time = T·DM·TM,
Auto Travel Time = T·DM.

The levels of travel cost used in the design were:

Transit Cost = $3.00, $2.00, $1.00, $0.50.

Auto travel cost, which represented parking cost in the SP scenarios, was fixed at $3.00 for all individuals. The SP questions were then framed as follows (example travel time and cost values are shown).

*Pre SP Question*

"Suppose you are making a commute trip from home to work and you have the following two alternatives available to you:

Take Public Transit: Travel Time = 21 min.; Fare = $1.00
Drive Your Car: Travel Time = 15 min.; Parking = $3.00

"Based on the above alternatives, how likely would you be to take public transit?

1. Very likely
2. Likely
3. Undecided
4. Unlikely
5. Very unlikely"

Post SP questions were given in the same format, but after the following statement:

*Post SP Question*

"For the following questions, assume that transit information systems similar to the one which you have experienced today are widely available for your use at home, in shopping and work locations, and at kiosks at transit stops."

*Assignment of SP Parameters:* The travel time parameters each have three levels, while the transit cost parameter has four levels, yeilding 36 distinct variations of parameter levels. After a preliminary inspection of the parameter combinations, it was decided to eliminate the cases with transit cost of $3.00 (which equals the auto parking cost) when the transit-to-auto travel time ratio was 0.8 or greater, rather than use an orthogonal design. This led to a total of 30 combinations that were used in the experiments.

Each subject was given six SP questions before and after the experiment with the prototype. With 48 subjects recruited for a complete factorial design, the 30 variants were on average repeated 19.2 times, And randomly assigned to subjects. Combinations in which transit had more preferable attributes than auto received higher probabilities of assignment.

*Analysis of SP Responses:* The resulting data were analyzed by applying the log-linear model [4] to a four-way classification table defined by (1) travel time ratio, (2) transit fare, (3) likelihood of choosing bus, and (4) before and after indicator. An inspection of the table indicated that the subjects exhibited logical response patterns where the indicated likelihood to choose transit was greater when transit had less time or cost less. The focus of this study, however, is not to probe into the trade-off between travel time and travel cost; rather, it has been the objective of this SP experiment to examine the hypothesis that using a transit information system affects the user's preferences toward public transit.

This hypothesis is examined by estimating alternative log-linear models and analyzing whether the classifying factors used to define the table have significant main and interaction effects. Let "R" stand for the response to the SP question, "E" for before and after indicator, "C" for transit travel cost, and "T" for travel time ratio. The effects of the respective main and interaction effects are summarized in Table 2.

The main effects in the table represent the degree of uniformity of the marginal frequency distributions of observations with respect to the respective variables. For example, the significant main effect for R, response to the SP questions, indicate that the marginal distribution of this variable is significantly different from a uniform distribution. The insignificance of the main effect of E, before/after indicator, is logically expected because this factor was controlled to have a uniform distribution during the experiment (it is not exactly uniform due to four missing observations). Of the two-way interactions, RC and RT are highly significant (at a 1% level); response to the SP questions (R) are strongly associated with transit travel cost (C) and travel time ratio (T) (recall that auto travel cost was fixed at $3.00 during the experiment).

Quite important is the result that none of the interaction terms involving before/after indicator (RE, EC and ET) is statistically significant at a 10% level. In particular, EC and ET have extremely small chi-square statistics, indicating that the distribution of responses with respect to transit travel cost or travel time ratio did not change before and after the experimentation with the prototype. The insignificance of RE indicates that the distribution of responses to the SP questions is not statistically associated with the before/after indicator, i.e., the way subjects responded to the questions did not change before and after the use of the prototype.

Along with the result that all three-way interaction terms are insignificant, this analysis with the log-linear model offers clear indications that the way subjects responded to the SP questions did not change before and after the use of the prototype. The analysis of this section is preliminary in the sense that the subjects' attributes are not incorporated and no provision is made to account for the repeated measurement issue. The latter, however, tends to lead to the problem of overstated significance of effects; therefore the conclusions drawn here, which are based on insignificance of effects, are unlikely to be invalid. Furthermore, it is highly unlikely that the apparent insignificance of the before/after indicator has been caused by the omission of subjects' attributes. It is therefore unlikely that the conclusion drawn here needs to be modified.

Table2
**Log-Linear Model Analysis of Before-After SP Data**

· Simultaneous Test That All Factor Interactions Higher Than K Are Zero

| K-Factor | df | $\chi^2$ | $\alpha$ |
|---|---|---|---|
| 0-Mean | 239 | 336.86 | 0.00 |
| 1 | 224 | 229.83 | 0.38 |
| 2 | 159 | 103.86 | 1.00 |
| 3 | 54 | 39.34 | 0.93 |
| 4 | 0 | 0.00 | 1.00 |

· Simultaneous Test That All K-Factor Interactions Are Simultaneously Zero

| K-Factor | df | $\chi^2$ | $\alpha$ |
|---|---|---|---|
| 1 | 15 | 107.03 | 0 |
| 2 | 65 | 125.97 | 0.00 |
| 3 | 105 | 64.52 | 1.00 |
| 4 | 54 | 39.34 | 0.93 |

· Significance of Individual Effects

| Effect | df | $\chi^2$ | $\alpha$ |
|---|---|---|---|
| R | 3 | 24.94 | 0.00 |
| E | 1 | 0.02 | 0.88 |
| C | 3 | 28.35 | 0.00 |
| T | 8 | 46.75 | 0.00 |
| RE | 3 | 5.83 | 0.12 |
| RC | 9 | 63.65 | 0.00 |
| RT | 24 | 67.53 | 0.00 |
| EC | 3 | 0.11 | 0.99 |
| ET | 8 | 0.31 | 1.00 |
| CT | 18 | 24.43 | 0.14 |
| REC | 9 | 4.51 | 0.87 |
| RET | 24 | 25.09 | 0.40 |
| RCT | 54 | 33.00 | 0.99 |
| ECT | 18 | 1.24 | 1.00 |

R= Response (likelihood of choosing bus)
E= Before/after; C= Transit cost; T= Travel time ratic

## 7. Valuations of the Prototype

User preferences and valuations of transit information system are inferred in this section based on the analysis of responses to the questions administered at the very end of the session. The questions included the following:

"Would you rate the usefulness of the information system you just used?"
"If you were purchasing an information system, how

would you most like the information provided?"

"If such a system was available, how would you most like to use it?"

"If such a system was available, where would you most like to use it?"

"How would you most like to give input to the system?"

"If a transit information system, similar to what you just experienced were available on the market today, how likely would you purchase such a system?"

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

"If such a system were available at a monthly charge just like cable TV, how much would you be willing to pay for this service?"

A set of response categories was provided to each question. Table 3 presents a summary of responses.

*Would you rate the usefulness of the information system you just used?:* Forty-three of the 48 subjects who participated in the experiment indicated that the information system was either useful or very useful. Only four subjects (8%) indicated that they were uncertain about its usefulness, and one subject (2%) felt it was of little use. Overall it is evident that pre-trip transit information systems like the prototype used in the experiment will be considered as a useful system.

Female subjects tended to give higher ratings to the system than did male subjects. This is consistent with the previous finding that female commuters tended to acquire pre-trip traffic information more than did their male counterparts [5]. The association between age and system valuation is very strong (significant at a 5% level). Fifty percent of those subjects who were over 40 years old rated the system as "very useful," while the corresponding percentage is only 21% for the younger group. As the following discussions indicate, age turns out to be an important factor that affects individuals' valuations and preferences of such an information system.

*How Would You Most Like the Information Provided?:* The response categories provided for this question were: graphics; text; voice; text and graphics; text and voice; graphics and voice; and text, graphics and voice. Over a half of the subjects preferred the conventional media of either text or graphics, while over a quarter preferred voice. A tabulation by income suggested that the lower income group tended to prefer either text or graphics while the higher income group tended to prefer less conventional media.

*How Would You Most Like to Use the System?:* Although weak, there is an indication that vehicle-miles driven per year is associated with the communication media through which subjects wanted to use the system. Those who traveled over 10,000 miles a year tended to prefer using kiosks and other means, while others tended to prefer the modem. Consistent with this is the result that those subjects whose usual commute mode was driving alone preferred Kiosks and other means. These results are intuitively agreeable and suggest that mobile people seek communications media that offer ubiquitous access to an information system.

*If such a system was available, where would you most like to use it?:* Responses to this question are uncorrelated with most of the personal and commute trip attributes examined in this study. The only variable which showed a moderate association with it is work schedule flexibility; those subjects with flexible work schedules tended to indicate that they would use the system in the automobile or on roadside more often than those with fixed schedules.

*How would you most like to give input to the system?:* Age is strongly associated with how subjects wanted to give input to the system. Those subjects who were over 40 years old preferred the keyboard or touch screen as the input media while the younger subjects preferred the mouse more than statistically expected (significant at a 5% level). Evidently older individuals prefer more traditional media while younger individuals are more inclined toward the use of more recently developed devices.

*If a transit information system, similar to what you just experienced were available on the market today, how likely would you purchase such a system?:* A total of 11 subjects (24%) indicated they were either "very likely" or "likely" to purchase a system, while 15 (33%) said they would do so "with modification" and 17 (38%) said "in the future." There were two subjects (4%) who said they were not likely to purchase. A majority of the subjects was not prepared to purchase a system similar to the prototype with which they experimented.

Age and education are strongly associated with the intention to purchase a system. Surprisingly those over 40 years of age tended to indicate they were either likely or very likely to purchase (significant at a 2% level). This may be an indication that older individuals prefer to plan things they do and are more willing to take time to go through information material. It is however possible that this merely represents affirmative bias that is typically found in responses to this type of question. Namely, subjects tended to give answers that they thought the survey designer wanted to hear, and this tendency was more prevalent among the older subjects.

The association between education and the intention to purchase is significant at a 10% level. Those with college education indicated they were likely or very likely to purchase a system more often than expected. This is agreeable as those with higher education can be expected to be able to make use of a system even when it is complex to use. It is also expected that people with higher education are more accustomed to the use of computers and therefore have less hesitation in acquiring a information system like the prototype used in this study.

*If you were to buy such a system, how muchwould you be willing to pay?:* Using the mid-points of the response categories provided with this question, the average purchase price the subjects were willing to pay is estimated to be $67.

*If such a system were available at a monthly charge just like cable TV, how much would you be willing to pay for this service?:* The average amount is $11 per month. Age turned out to be significantly associated with the amount subjects were willing to pay to rent such a system. The difference in the averages is small ($12 for the younger group and $10 for the older group). A further inspection indicated that the number of subjects who were not willing to pay $5 a month or more is much greater in the older group; that the younger group has a tight distribution that concentrate in the $5 to $20 range; while the older group has a distribution that is more spread.

## 8. Conclusion

A realistic, PC-based transit pre-trip information prototype was used in laboratory experiments of this study to evaluate how such a system may be used and evaluated by potential users, and how it may affect users' attitudes toward public transit. The results of the study indicated that route maps and schedules are the most important pieces of information when planning a transit trip to a specific destination by a specific time. The subjects of the experiments overall had favorable evaluations of the system. The subjects' ratings of the system indicated that age is an important variable that defines market segments for such information systems.

The prototype in principle functioned as aninformation look-up device. As such, it is not clear whether a mouse/keyboard driven, PC-based system may excel conventional route maps and printed time tables. In fact the average time of nearly 10 minutes on the prototype to find a bus to take to a pre-specified destination, appears to be excessive. A system must have capabilities to identify geographical locations, generate alternative travel options, and suggest destination opportunities. The experimental tasks employed in this study should not represent typical use of transit information a system.

The study results also indicated that the use of the prototype had no effect, either positive or negative, on subjects' attitudes toward, and valuation of, public transit. This, however, may be due to the limited capabilities of the prototype. For example, the availability of dynamic information (e.g., when the next bus is arriving) may have tangible impacts upon perception.

The study results point to the need for automated route searching capabilities, i.e., the user inputs the origin (if applicable) and destination, and the time by which he/she wishes to arrive at the destination (or the time at which he/she can leave the origin), then the system offers recommended bus lines and departure times. One focus of future user interface development, then, would be on how to make it simpler for the user to input origin-destination locations or to locate an opportunity which serves his/her needs.

## References

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Table 3
Distribution of Responses to End Questions

a. By Parking Availability at Work

| Very Useful | Useful | D/K | Little Use | No Use | Total | Score |
|---|---|---|---|---|---|---|
| 17 | 26 | 4 | 1 | 0 | 48 | 4.2 |
| 35 % | 54 % | 8 % | 2 % | 0 % | 100 % | |

b. Distribution of Responses to Question:

| Graphic | Text | Voice | Text + Graphics | Text + Voice | Graphics + Voice | Text, Graphics +Voice | Total |
|---|---|---|---|---|---|---|---|
| 11 | 14 | 13 | 9 | 1 | 0 | 0 | 2.38 |
| 23 % | 29 % | 27 % | 19 % | 2 % | 0 % | 0 % | 100 % |

c. If such a system was available, how would you most like to use it?

| Toll Free | Phones | Modem | Kiosks | Others | Total |
|---|---|---|---|---|---|
| 13 | 4 | 17 | 13 | 1 | 48 |
| 27 % | 8 % | 35 % | 27 % | 2 % | 100 % |

d. If such a system was available, where would you most like to use it ?

| At Home | In Auto | Road-side | Shopping Malls | Air-port | Rail Station | Bus Terminal | Near ATM | Other | Total |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 6 | 14 | 17 | 1 | 3 | 0 | 0 | 0 | 48 |
| 15 % | 13 % | 29 % | 35 % | 2 % | 6 % | 0 % | 0 | 0 % | 100 % |

e. How Would you most like to give input to the system?

| Touch Screen | Key-board | Mouse | Voice | Other | Total |
|---|---|---|---|---|---|
| 6 | 6 | 14 | 17 | 2 | 45 |
| 13 % | 13 % | 31 % | 38 % | 4 % | 100 % |

f. If a transit information system, similar to what you just experienced were available on the market today, *how likely would you purchase such a system?*

| Very Likely | Likely | With Mod. | In the Future | Not Likely | Total | Score |
|---|---|---|---|---|---|---|
| 5 | 6 | 15 | 17 | 2 | 45 | 2.9 |
| 11 % | 13 % | 33 % | 38 % | 4 % | 100 % | |

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

| None | < $20 | < $50 | < $100 | < $200 | < $500 | ≥$500 | Total | Avg. |
|---|---|---|---|---|---|---|---|---|
| 5 | 6 | 15 | 17 | 2 | 3 | 0 | 48 | $67 |
| 10 % | 13 % | 31 % | 35 % | 4 % | 6 % | 0 % | 100 % | |