RESULTS OF THE UTRACS INTERNET-BASED PROMPTED RECALL GPS ACTIVITY-TRAVEL SURVEY FOR THE CHICAGO REGION

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ABSTRACT
This paper presents the results of the Urban Travel Route and Activity Choice Survey (UTRACS), which is an internet-based prompted recall activity-travel survey using GPS data collection combined with a short activity preplanning and scheduling survey implemented in the Chicago region. The survey, while collecting the standard household travel survey type questions, also collected data regarding the activity planning and scheduling process undertaken by individuals. Data regarding the planning process, including spatial, temporal and interpersonal flexibilities and planning horizons for the activity itself as well as plan horizons for various attributes of the activity, were all reported during the prompted recall portion of the survey. The survey was conducted by a sample of 100 households, with the households evenly divided into elderly and non-elderly households. Survey respondents carried a portable GPS device for 14 consecutive days and at the end of each day uploaded the collected data to a website where the activity-travel survey questionnaires were answered.

Details about the survey sample characteristics and initial results in terms of activity-travel indicators and observed activity planning behaviors are reported, as well as an analysis of the data quality. Results indicate that the quality of the data collected is good and that the response rates were satisfactory. Altogether, the survey provides important information regarding activity-travel behavior in the area and the nature of the activity-travel planning process and will allow greater insight into the needs and motivations of travelers in the region.

INTRODUCTION
The growth of travel demand management policies such as congestion pricing and encouragement of telework makes travel demand models' sensitivity to changes in travel behavior a necessity if one wishes to evaluate the effects of these policies (*1*, *2*). To attend this need, travel demand modeling techniques evolved from trip to activity-based models. More detailed and accurate data is necessary to validate and calibrate these new models. The limited data regarding the decision-making process associated with activity engagement and travel, not typically collected in activity and travel surveys, has been a critical issue for the development of more behaviorally sensitive models (*3, 4*). In response, travel survey methods have also evolved, making use of computer assisted telephone interview (CATI) surveys, computerized surveys and, more recently, with the popularization of broadband, internet surveys. The development of the Global Positioning System (GPS) technology makes it now possible to passively collect data about a considerable portion of the traditional activity and travel attributes of interest (*5, 6*). The many advantages of GPS surveying are described in (*7*). Among these is the facilitation of the creation of maps displaying the observed activity-travel pattern which can prompt respondents' memories when answering survey questionnaires (*8, 9, 10, 11*). Mobile phone technology has also been used with similar purpose (*12*).

At the same time as computers and location technology evolved, the world's population, especially that of developed countries, grew older. In 2007, there were 37.8 million persons age 65 and older in the United States. While the total population of the country is expected to increase by 29.2% from 2000 to 2030, the number of elderly is expected to increase by 104.2% (*13*). Older individuals typically have different life style than the rest of the population. They are often retired and therefore have a very different activity-travel pattern than the basic home-work-home. Also, they frequently have mobility constraints that make their travel needs unique (*14*). All these facts make aging an important point of concern for transportation planners. In this context, this work relates the implementation of an automated GPS-based prompted recall survey over the internet that, besides collecting traditional activity-travel survey data, collects data on individuals' decision-making process. A sample of half elderly and half non-elderly households was surveyed, which will allow the exploration of differences in the travel behavior of younger and older individuals in a later stage of the project.

The objective of this paper is to describe the implementation of this survey and to analyze the quality of the data collected. This survey is justified by claims of modelers in need for more data regarding travelers' decision-making process (*2, 3, 4*) and the data proceeding from this collection effort will hopefully contribute to enlarging the understanding of the travel-activity decision-making process of the general population. The data collected will enable the calibration of an agent-based dynamic activity planning and travel scheduling (ADAPTS) model currently under development at the University of Illinois at Chicago (UIC) (*1*). This data can also be used to analyze behavioral peculiarities associated with older individuals. Further discussion on the justification and need for such a survey, as well as its possible applications, is found in (*2*).

METHODOLOGY

This survey was conducted using an automated GPS-based prompted recall survey over the internet, combining passive and active data collection. Besides collecting traditional activity-travel diary data such as purposes, travel modes, times, distances etc, the survey also collects decision-making process data by asking participants about how and when they planned their activity and travel attributes. Details of the survey design and information about the pilot study can be found elsewhere (*2*). Each respondent participated in the survey for approximately fourteen days. The survey collected daily data on activity-travel patterns, planning horizons, flexibilities, persons involved and travel costs. In addition, the survey registered the schedule evolution and the observed outcome for a single set day for each respondent during the survey period.

The data collection had three parts. The first part was completed when respondents joined the survey and consisted of user registration, socio-demographic, routine activities, and frequently visited locations surveys. The routine activities and frequently visited locations input allowed the survey software to automatically identify activity and travel attributes and avoid repetitive queries. This was implemented, in response to pilot feedback (*2*), with the goal of reducing respondent burden in the long run. For the routine activities, the survey displayed a tabular format and users could input the activity type, location, persons involved, start, end time and their variability, as well as days of the week when that activity was routinely performed. For the frequently visited locations, a Google map was displayed and respondents could enter the location address or close intersection. The exact location point within a block or large building may be specified dragging a pointer.

The second part consisted of a periodic activity planning survey. Data on activity type, location, start and end time, travel mode, and persons involved was collected for a fixed day, which was 8 days after the user registration date. The planning survey page is shown in Figure 1(a). This survey was repeated at 3 and 1 day before the "preplanning day". Because different attributes of an activity or trip have different planning horizons (*15*), the survey allowed respondents to enter only the attributes which were known for the planning day as well as for the routine activities. For example, if an individual planned an activity of a certain type, but not all persons involved or activity locations were known, he would enter on his schedule only the activity type. The outcome of the planning day was recorded with a GPS device during the course of the next part of the survey.

In the final, major part of the survey, respondents carried a cell phone-sized personal GPS logger for two weeks and uploaded their logs on the survey website at the end of each day. Uploading was made as easy as possible. It consisted of connecting the logger to the computer with an USB cable and clicking ok on an auto play window which ran the code to process the GPS data. The login page of the survey website was automatically loaded with the username, so respondents only had to enter their password and select the processed file to upload.

The data in the log file was transferred to a web server and analyzed to produce a timeline and a map displaying the automatically detected activities and trips. These algorithms are described in (*2*). Respondents were able to visualize their activity-travel pattern on both a Google map as well as a simple timeline next to the map. Then, they were prompted to correct errors in the log associated with signal acquisition delay, bad satellite fixes or occasional failures of the location finding algorithm. Tests demonstrated that the processed GPS data captures over 97% of all activities and 87% of the automatically detected activities are accurate (*2*). Activities and trips could be added, deleted or have their start, end time and location modified. After each addition, a new map incorporating the changes was displayed to respondents. This website page is shown in Figure 1(b). The map could be zoomed in and out, scrolled and visualized as a satellite image. The presentation of the activity-travel pattern in an interactive and familiar display such as a Google map, also connected to an activity timeline, made participation more attractive and interesting, possibly lightening respondent burden.

After user verification was done, the survey software generated a questionnaire for each activity and trip undertaken. Next to the questionnaire, respondents saw a map displaying the activity location or the trip route which the questionnaire referred to, and their respective dates, start and end times, and location name, when known. The visual information eliminates possible doubts about which event the questions refer to and prompts respondents' memories about the event. For travel episodes, questions regarded mode (including multiple modes), costs, when and why decision for using mode were made, and why the respondent chose to take the displayed route. For activity episodes, questions regarded activity type, persons involved, activity, location, start time and duration planning horizons as well as location, start time and duration flexibilities. Figure 1(c) and 1(d) show the website page with the activity and trip visual representations and questionnaires.

All answers were multiple choice and in the end of each questionnaire there was a comment box where respondents could input any answer which was not satisfactorily captured by available answers. To reduce respondent burden, the answer for the travel mode, location name, activity type and persons involved might be auto-populated by a learning algorithm, described in (*2*). Suggestions were only made when the likelihood of the predicted answer being correct is very high (*16, 17*). If the answer suggested was incorrect, respondents could simply choose the correct answer as they would do if there was no auto-population.

Survey Equipments

The equipment used in this survey consisted of GPS trackers, rechargeable AAA batteries, chargers and computers with internet connection. The GPS tracker has a storage capacity of approximately 360 hours of tracking data and can operate for 15 continuous hours. It weighs approximately 50 grams, not including batteries. The GPS tracker is driverless and the codes that process the raw data recorded by the GPS tracker are stored in the device itself. The survey software is hosted in the web server. In this manner, no file has to be installed in the computer where the survey is taken. The survey code is written in ASP.NET, and utilizes JavaScript to run the Google Maps API mapping software. The data processing algorithms contained in the GPS device are coded in Java. This allows any computer with a working USB port, mouse, screen, internet connection and Java Runtime Environment to be used for the survey. Thus, respondents have the flexibility to complete the survey using different computers if they wish to do so.

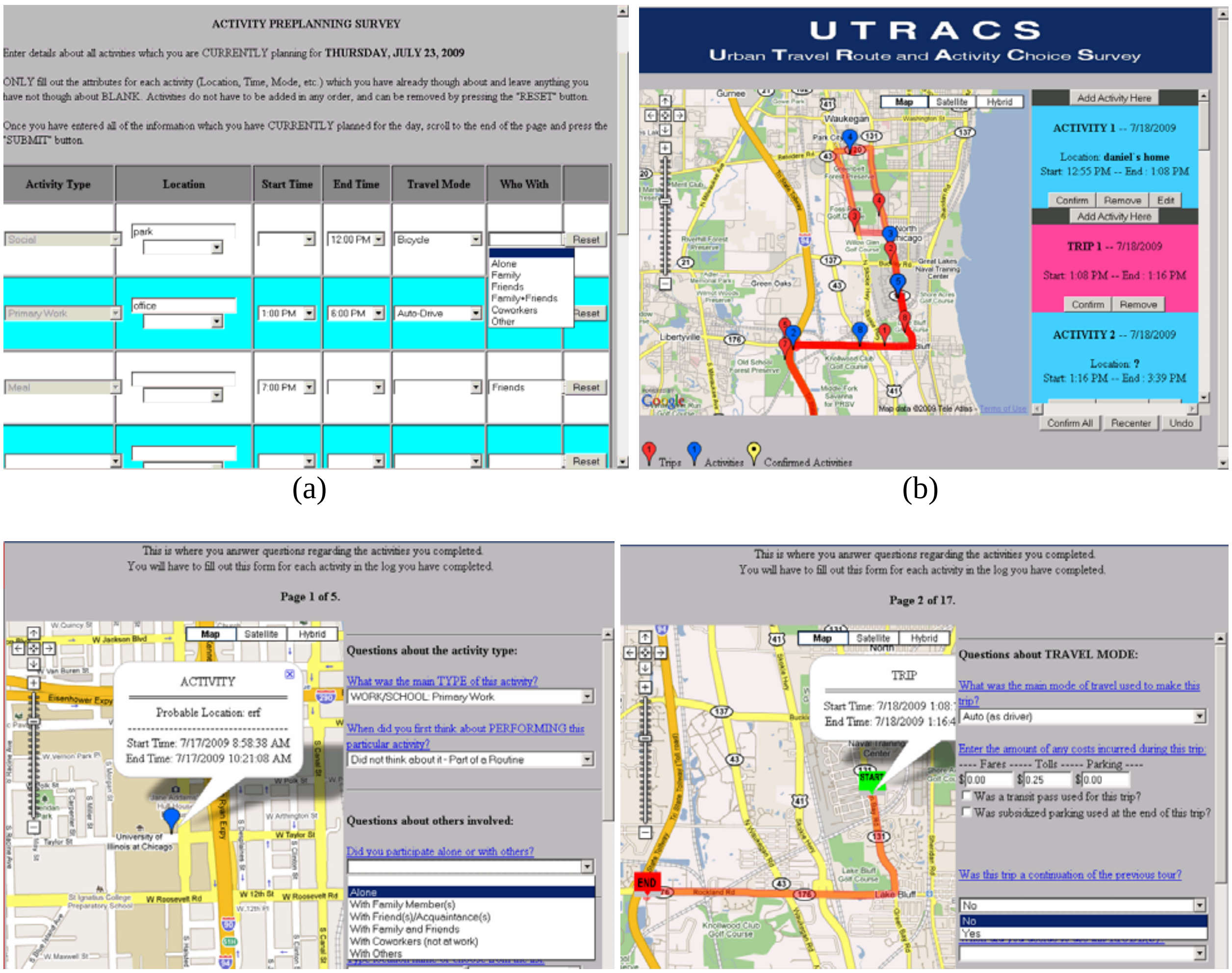


FIGURE 1 Survey Website: (a) Planning day survey, (b) Activity-travel pattern confirmation, (c) Questionnaire about activities, (d) Questionnaire about trips.

SURVEY IMPLEMENTATION

GPS and internet surveys are largely an experimental procedure at this time (*18*). Therefore no standardized guidelines for sample sizes, methods of drawing samples and methods for equipment deployment and retrieval are available for these types of survey. However both survey methodology and implementation procedures were designed to follow as closely as possible the procedures recommended in literature for traditional travel surveys.

Recruitment of Respondents

A total of 100 households in the Chicago area are surveyed. Respondents were recruited from a random stratified sample of the Chicago area population. Half of the sample was constituted by individuals age 65 and over and the other half of ages 16 to 64. The geographical area included Cook, DuPage, Lake and Will counties. This sample was stratified by county and by four categories of income. The sample followed the geographic population distribution existing in Census 2000. However, because of past experience of lower response rate among lower income and lower education households (*14*), those falling in the lower income categories were oversampled to yield a final income distribution similar to that of Census 2000.

Familiarity with computers was not required from respondents since the survey requires little computer knowledge, and training and assistance were thoroughly provided. For those households that did not possess a working computer and internet connection, laptops with dial-up or wireless broadband were provided. Assistants either left the laptops and the internet data card in the households for use during the survey period or they visited households taking the equipment every two or three days.

The incentives for participation were a 25 dollars debit card for each respondent in the household, and the entry into a drawing to win one grand prize of 500 dollars or one of two first prizes of 250 dollars, also in form of debit cards. Respondents were entitled to the 25 dollars card after the completion of the upfront surveys and two days of survey. The drawing of the three prizes had the goal of incentivizing continued participation through the 14-day survey period and respondents got one entry for each day they uploaded data and completed the associated questionnaires.

Recruitment of respondents and their participation in the survey had the following life cycle: 1 - mailing of invitational material, 2 - invitational phone call, 3 - initial visit for equipment delivery and training, 4 - assistance during the course of the survey, and 5 - exit visit for equipment retrieval and incentive delivery.

DATA VALIDATION

A total of 110 individuals in 102 households completed the survey. Forty-nine percent of respondents were seniors - 65 years-old or over - and the other 51% were between 18 and 65 years-old. Data on 2,610 trips and 2,774 activities was collected from the seniors and on 3,020 trips and 3,124 activities from the younger respondents, totaling 5,630 trips and 5,968 activities. The trip rate was 4.3 trips per person per day, which indicates an above average number of trips when compared to the reference trip rate for personal travel suggested in (*18*), 3.4 trips per person per day. This result is consistent with the finding of previous studies which demonstrate that GPS surveys have improved ability to capture trips which are frequently under-reported in other types of survey. The non-mobility rate was 9.35%, falling in the range suggested as accurate in (*20*). This result is also similar to other long duration surveys such as the seven-day German Mobility Panel and the six-week Mobidrive, which are considered to have accurate non-mobility levels (*20*).

Response Rate

The response rate was calculated using the American Association of Public Opinion Research (AAPOR) RR3A formula:

$$RR3A = \frac{SR}{(SR + PI) + (RB + O) + e_A (UH + UO + NC)}$$

where

$RR3A$ = response rate
SR = complete interview/questionnaire
PI = partial interview/questionnaire
RB = refusal and break-off
NC = non-contact
O = other
UH = unknown if household occupied
UO = unknown other
e_A = estimated proportion of cases of unknown eligibility that are eligible

The proportion of cases of unknown eligibility which are eligible was estimated as the rate of ineligible individuals to all contacted individuals. Under 3% of households to which a phone contact was attempted were considered ineligible due to having health conditions which does not allow travel or survey completion, moving out of the study area or wrong contact information. This yields to an estimated e_A of 0.8853.

The overall response rate, in terms of persons, was 11.95%, and in terms of households, 11.31%. This response rate is low when compared to traditional one or two-day pen-and-paper travel surveys, but is satisfactory for a more complex two-week GPS-based internet survey that requires a greater commitment from respondents. Other long-duration surveys had comparable response rates (*21, 22*). The cooperation rate, which is the ratio of respondents to eligible persons contacted, was 17.36%. The response rate for the elderly was 9.65%, lower than that for the non-elderly, which was 14.67%. This result is consistent with (*23*), who found that households with elderly individuals have a higher refusal rate. The lower survey acceptance among older individuals is probably due to the survey being internet-based. In fact, the most common reason why elderly individuals refused to participate in this survey was the need to use a computer, even though a laptop with mobile broadband internet connection was offered to those without computer or internet access. Some elderly are not familiar with computer technology and do not desire to deal with it even if assisted. However, as years go by this problem should become less of an issue since the aging population will likely yield more elderly that are computer literate.

Sample Bias

Bias is a systematic error that may occur in the data collected from a sample of the population because individuals with certain characteristics may be more likely to be included in the sample than others. Accordingly to the recommendations in (*18*), the following variables are tested for sample bias: household size, vehicle availability, household income, age, race and gender. The categories tested for each of the variables above were aggregated when compared to the recommendations cited due to reduced sample size of this survey. The total error is measured using the percentage root mean squared error (RMSE):

$$PercentRMSE = \sqrt{\frac{1}{n_i}\sum_{i=1}^{n_i}\frac{1}{n_{ij}}\sum_{j=1}^{n_{ij}}\left(\frac{r_{ij}-s_{ij}}{r_{ij}}\right)^2} \times 100$$

where:

n_i = number of variables *i*;
n_{ij} = number of categories *j* in variable *i*;
r_{ij} = reference value of variable *i* in category *j;*
s_{ij} = sample value of variable *i* in category *j*.

The reference values were calculated with data from the American Community Survey for Cook, DuPage, Lake and Will counties. Table 1 presents the reference values and sample values for each variable mentioned. The geographic distribution of the respondents is also shown in Table 1 and is compared to that of the Census 2000. Cook County, which encompasses the city of Chicago and the core of the metropolitan area, is in a small part over represented, but overall, the distribution of respondents satisfactorily matches that of the study area population.

TABLE 1 Sample Bias

Variable	**Census: Elderly**	**Sample: Elderly**	**Census: Non-Elderly**	**Sample: Non-Elderly**
Geographic Distribution				
Cook County	77.27%	81.25%	71.80%	84.00%
DuPage County	10.88%	10.42%	12.32%	8.00%
Lake County	6.73%	6.25%	8.92%	6.00%
Will County	5.12%	2.08%	6.96%	2.00%
Household Size (Average)	1.91	1.82	2.93	2.81
Vehicle Availability				
No vehicle	21.90%	4.44%	10.83%	4.65%
1 or more vehicles	78.10%	95.56%	89.17%	95.35%
Household Income				
$34,999 or less	50.33%	22.22%	24.38%	15.79%
$35,000 to 49,999	14.37%	19.44%	12.92%	21.05%
$50,000 to 74,999	14.97%	16.67%	19.63%	13.16%
$75,000 to 99,999	7.85%	22.22%	14.63%	15.79%
More than $100,000	12.49%	19.44%	28.44%	34.21%
Race				
White	73.55%	82.00%	61.12%	80.39%
Black/African American	17.37%	16.00%	19.12%	11.76%
Other	9.07%	2.00%	19.77%	7.84%
Gender				
Male	39.76%	34.00%	47.31%	30.77%
Female	60.24%	66.00%	52.69%	69.23%
Age				
18 to 44 years-old	-	-	61.33%	32.69%
45 to 64 years-old	-	-	38.66%	67.31%
65 to 74 years-old	51.74%	68.00%	-	-
75 years-old and over	48.26%	32.00%	-	-

For the elderly subset, the RMSE is 49.15%. The sample characteristic that most contributed to the inflation of the RMSE for this subset was household income, because of the over representation in the sample of elderly households with income between $75,000 and $99,999 per year. For the non-elderly, the RMSE is more satisfactory: 38.53%. For this subset, age was the most critical characteristic because of a lower participation of individuals younger than 45 years-old.

Trip and Activity Attributes

A summary of the trip and activity attributes collected is available in Table 2. The attributes are compared against those observed at the Chicago Metropolitan Agency for Planning (CMAP) 2008 Travel Tracker Survey (*24*). The Travel Tracker is a multimode household travel and activity survey which was collected from 10,552 households in a 1 or 2-day survey on the Chicago metropolitan area. Telephone interviews were the primary data collection mode. Over 23,000 individuals participated in Travel Tracker, out of which 4,315 were ages 65 and over. Table 2 displays the average number of activities by type per person per day and the percentages of accompanying persons, travel mode, trip duration, daily travel time, trip distance and automobile and bus speeds for the elderly and non-elderly subsets. The trip distance available on the Travel Tracker Survey is the straight line distance from one activity to the next. The reference values for trip distance displayed in Table 2 were increased by 20% to estimate the real distance traveled (*25*). Average speeds were calculated as trip distance (estimated real trip for CMAP survey) divided by travel time.

Table 2 reveals that respondents reported a higher activity rate per person-day for almost all types of activities. Noticeably, at least 50% more shopping activities were reported in this survey than in the reference. The automated recording and detection of activities made possible that minor shopping activities such as stopping on the way and buying a drink be reported at a higher frequency. The same effect occurred to changes in transportation. Because these are usually short activities and people tend to think they are unimportant, the automated survey mode yielded a lot higher rate of this type of activity than that observed in the reference, both for elderly and non-elderly population. Social/leisure/recreation and, specifically for the elderly, civic and religious activities were also observed in a higher rate here. For accompanying persons and travel mode, this survey had comparable shares to the Travel Tracker. On the other hand, consistent with findings of previous studies, this survey registered more short duration and more short distance trips. The total daily travel time is overall lower, especially for younger travelers, and average automobile and bus speeds are higher. This result corroborates suspicions that self-reported surveys overstate travel time and provides another indication of the improved activity/trip reporting achieved with the use of GPS technology.

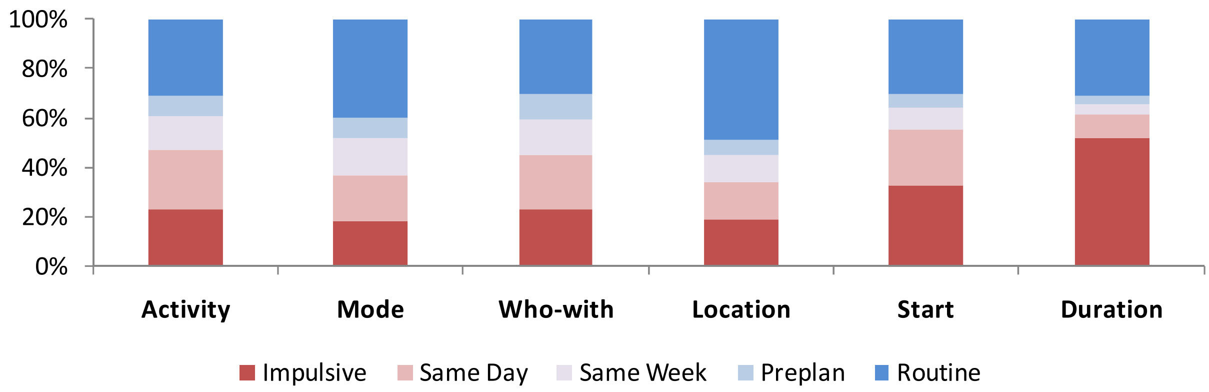
TABLE 2 Summary of Trip and Activity Attributes

Attribute	Value	CMAP Survey: Elderly	UTRACS: Elderly	CMAP Survey: Non-Elderly	UTRACS: Non-Elderly
Average Number of Activities by Type per Person-Day	Change transportation	0.0200	0.1128	0.0645	0.0707
	Healthcare	0.1197	0.1575	0.0683	0.1394
	Social/leisure/recreation	0.3364	0.6486	0.3467	0.4505
	Meal	0.2248	0.3267	0.2550	0.2323
	Other	0.4067	0.6040	0.5443	0.4747
	Personal Business	0.1479	0.2374	0.1297	0.1495
	Work	0.1880	0.0541	0.7745	0.6646
	Religious/Civic	0.1016	0.2186	0.0560	0.0586
	School	0.0028	0.0165	0.0315	0.0444
	Shopping	0.5532	1.0787	0.4761	0.7293
Share of Accompanying Persons	Alone	68.10%	55.71%	70.20%	65.14%
	With Others	31.90%	44.29%	29.80%	34.86%
Share of Travel Mode	Auto drive	71.38%	72.35%	72.21%	78.28%
	Auto passenger	16.91%	13.70%	10.32%	11.85%
	Bicycle	0.41%	0.36%	1.03%	0.41%
	Bus	1.89%	5.35%	1.93%	1.01%
	Commuter rail	0.38%	0.76%	1.80%	1.15%
	Light rail	0.29%	0.81%	1.57%	0.92%
	Walk	7.29%	6.31%	9.47%	5.42%
	Other	1.46%	0.36%	1.66%	0.97%
Share of Trip Duration	1 to 15 minutes	64.21%	77.31%	59.66%	75.42%
	15 to 30 minutes	22.30%	16.36%	22.07%	19.31%
	30 to 45 minutes	6.35%	4.18%	8.24%	4.30%
	45 to 60 minutes	3.36%	0.90%	4.88%	0.52%
	More than 60 minutes	3.78%	1.25%	5.15%	0.46%
Share of Daily Travel Time	0 to 30 minutes	37.37%	37.67%	20.03%	33.27%
	30 to 60 minutes	19.57%	24.45%	18.53%	27.63%
	60 to 120 minutes	25.09%	25.77%	33.88%	28.21%
	More than 120 minutes	17.97%	12.11%	27.56%	10.89%
Share of Trip Distance	0 to 5 kilometers	55.40%	51.30%	49.70%	55.17%
	5 to 10 kilometers	21.00%	22.38%	18.10%	14.58%
	10 to 20 kilometers	13.50%	14.97%	15.20%	12.92%
	20 to 30 kilometers	4.90%	5.34%	7.10%	7.01%
	30 to 50 kilometers	3.40%	4.20%	6.10%	5.90%
	More than 50 kilometers	1.60%	1.81%	3.30%	2.40%
Share of Average Speed for Automobile Trips	0 to 30 km/h	61.51%	13.89%	54.30%	14.50%
	30 to 60 km/h	31.28%	69.38%	36.69%	66.14%
	60 to 90 km/h	5.68%	14.55%	6.99%	16.34%
	More than 90 km/h	1.53%	2.18%	2.02%	3.02%
Share of Average Speed for Bus Trips	0 to 30 km/h	82.31%	61.62%	89.53%	31.82%
	30 to 60 km/h	17.69%	38.38%	10.47%	68.18%

ACTIVITY PLANNING OBSERVATIONS

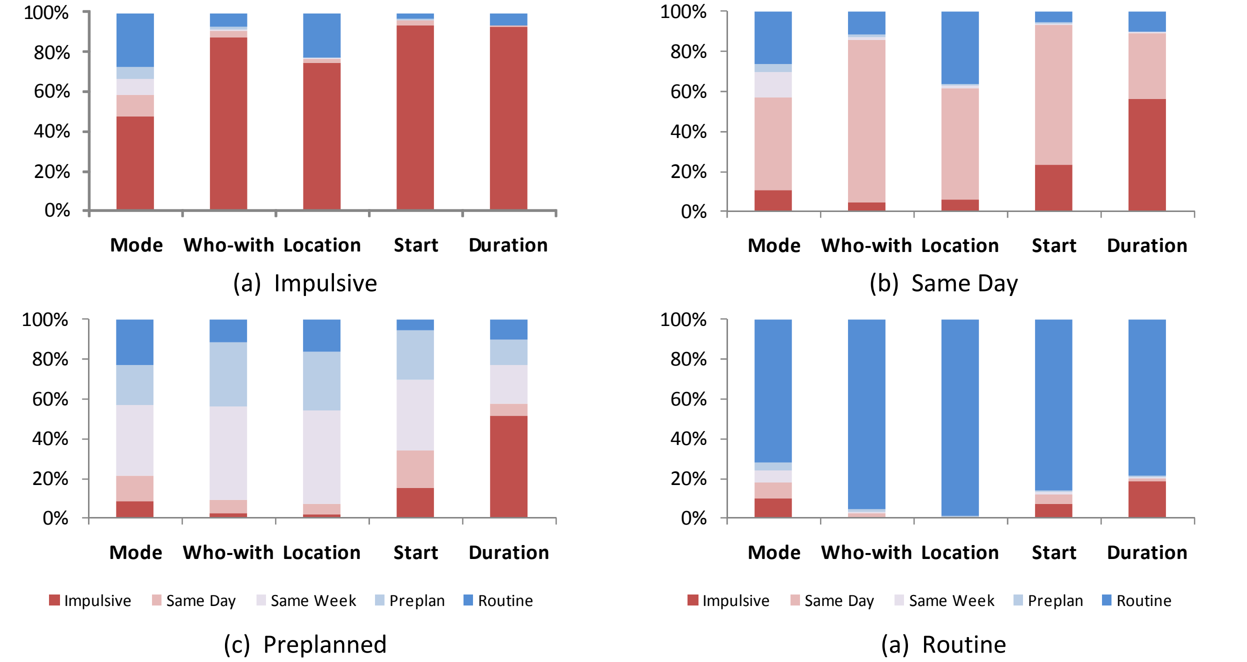
An important aspect of the UTRACS survey was the attempt to capture activity-travel *planning attributes*, i.e. when and how different activity participation and travel decisions were made. The planning attributes in the UTRACS survey were focused on the timing and constraints under which various planning decisions were made. Figure 2 shows the distributions for each of six planning horizon measures. These include the planning horizon for the overall activity (how far in advance of execution was the activity planned), and individual planning horizons for five specific activity attributes. The distribution shows how the planning for individual attributes differs from both the planning of the activity in general, as well as from each other, with the mode, party composition and location choices exhibiting more routine, less impulsive planning and the start time and duration choices showing more impulsive, less routine planning as compared to the overall activity plan distribution.

FIGURE 2. Activity and Activity Attribute Plan Horizon Analysis



It is perhaps more instructive to observe how the various attribute plan horizons vary with the overall activity horizon, in order to see a clearer picture of the dynamics underlying activity planning. Figure 3 shows the plan horizons for the five major attributes for four different overall activity plan horizons: impulsive, same day planned, preplanned and routine activities. It is clear immediately that activity planning does not occur all at once in an orderly fashion, with the various attributes decided as the activity is planned. In fact, significant deviations from simultaneous planning can be found. For example, over half of all activities planned for later in the same day or some later time have impulsively planned durations, meaning that many times even for preplanned activities, the actual durations are not decided on until the last minute. Even approximately 20% of routine activities have impulsive durations. Conversely, almost 40% of activities occurring impulsively or on the same day as they were planned occur at routine locations. These results show the complexity of activity planning, and motive future research into multivariate methods of analysis to further understand the activity planning process, which is enabled with the collection of this data.

FIGURE 3. Attribute Plan Horizon by Various Activity Plan Horizons



A final key activity planning process measure is the perceived degree of fixity of the various activity attributes. These fixity measures further define the activity planning process by providing a general measure of the constraints on planning at the time the decisions are made. The observed fixity measures for the five attributes are shown in Table 3. The results show that fixity varies, with little flexibility in location choice and involved persons, but with much flexibility in the start time and to a lesser degree the duration. The flexibility correlation matrix shows that there is very little correlation between the various flexibility measures.

TABLE 3. Attribute Flexibility Analysis

	MODE	*PER*	*LOC*	*STR*	*DUR*
Inflexible	58%	64%	74%	25%	47%
Flexible	42%	36%	26%	75%	53%

Flexiblity Correlations

	MODE	*PER*	*LOC*	*STR*	*DUR*
MODE	1.00				
PER	0.10	1.00			
LOC	0.06	0.11	1.00		
STR	0.11	0.19	0.04	1.00	
DUR	0.06	0.04	0.03	-0.02	1.00

CONCLUSIONS

The survey discussed in this paper has shown that prompted recall internet-based GPS surveys are an effective mode for travel surveying. This type of survey has the flexibility to allow respondents to answer the survey at the time and location of their convenience. They display clear and organized maps and questionnaires and provide means to automatically detect non-answered questions and days when the survey was not completed. In addition, online GPS surveys make data processing and analysis very expeditious. On the other hand, the extra equipment required and the added complexity associated with manipulating this equipment is a downside of these surveys. For this study, respondents were trained personally by a survey assistant on the steps required for survey completion, which increases survey implementation burden and cost. Experiments with different methods for respondent training and assistance are needed to explore the possibility of reducing implementation cost and increasing convenience for respondents. Online demonstration videos are a possible feature that might be effective for this purpose.

The response rates for this survey, 9.65% for the elderly and 14.67% for the non-elderly, are satisfactory considering the level of commitment associated with participation. Sample bias was measured regarding gender, sex, age, household size, income and vehicle availability. The RMSE is 49.15% for elderly subset and 38.53% for non-elderly. The characteristic that most contributed to the inflation of the RMSE was income for the elderly and age for the younger group. Geographic distribution of respondents satisfactorily matched that of Census 2000. The survey capability of warning respondents about unanswered questions before survey submission contributed to the achievement of a missing value index of 0.0483. Together with non-mobility rate below average and trip rates above average, these results likely indicate good data quality.

An analysis of activity and trip attributes revealed that the results from this survey are consistent with the previous findings which demonstrate that GPS surveys have improved ability to capture trips that are frequently under-reported in other types of survey. More shopping, social, leisure and entertainment, religious and civic activities and changes in transportation are found in this study than in the reference survey. Average automobile and bus speeds are higher and more short trips, both in terms of time and distance, were observed, leading to overall lower average total daily travel times. This result corroborates suspicions that self-reported surveys overstate travel time. Finally, the activity planning observations show that activity planning is a complicated, dynamic process with much variation in how activities are planned. Further analysis of the activity planning process, enabled by the collection of activity planning data is planned for future work.

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