Results and Empirical Analysis of Activity Planning from the UTRACS Prompted-Recall Survey

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Submission date: November 6, 2009.

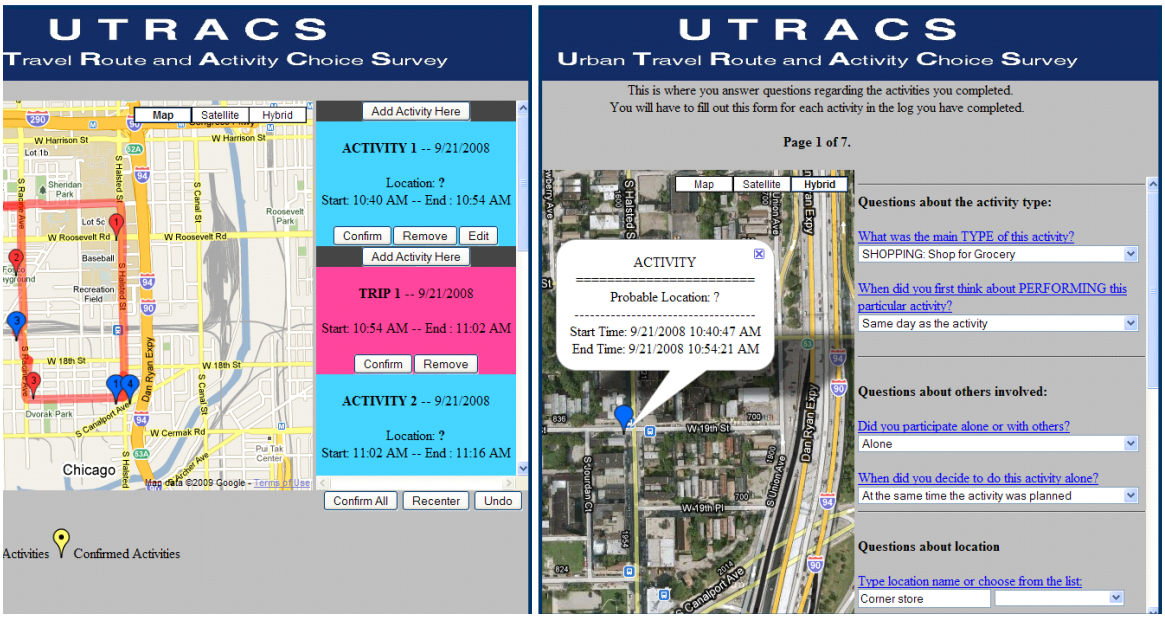
ABSTRACT
This paper presents the results of an internet-based prompted recall activity-travel survey using GPS data collection. Besides collecting traditional activity-travel diary data, this survey collects basic information about activity planning and scheduling process. Respondents carried a portable 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. Results indicate that the quality of the data collected is acceptable. The results reinforce previous findings that GPS surveys show improved ability to capture under-reported trips. The planning process data collected during the survey should help to improve models of the activity planning process.

BACKGROUND
Travel survey methods are continuously improving to keep up with the more diverse data requirements for advanced travel demand models (*1*, *2*). In the last ten years, the issue of collecting more volume of more accurate data on activity-travel patterns has been addressed by making use of GPS technology (*3*). At the same time, decision-making process data began to be collected by innovative survey methods such as CHASE (*4*). However, at the same time as computers and GPS technology evolved, the world's population is increasingly aging, especially in developed countries. As older individuals typically have different life style than the rest of the population (*5*) aging becomes 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. The objective of this paper is to describe the implementation of this survey and to analyze the quality of the data collected. 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 and to reveal specific behavior associated with older individuals. The data collected will enable the calibration of an agent-based dynamic activity planning and travel scheduling (ADAPTS) model currently under development (*6*).

METHODOLOGY AND IMPLEMENTATION
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 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 (*7*). 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.

Respondents carried a personal GPS data logger for two weeks and uploaded their logs on the survey website each day. The logs were uploaded to a web server and analyzed to produce a timeline and a map displaying the automatically detected activities and trips. The analysis filtered the raw GPS data for quality and clustered points into either trip or activity episodes based on a variety of context dependent distance, time and speed thresholds and previous location observations. Respondents were able to visualize their activity-travel pattern on both a

Google map as well as a simple timeline as shown in Figure 1a. They were prompted to correct errors in the log associated with signal acquisition, bad satellite fixes or occasional failures of the location finding algorithm. Tests demonstrated that the GPS processing algorithm determined activity locations with a sensitivity of 97% and accuracy of 87% (*7*). The display of the activity-travel pattern in an interactive and familiar display such as a Google map connected to an activity timeline, made participation more attractive and interesting and helped ease respondent burden. After user verification was done, the survey software generated a questionnaire for each activity and trip undertaken. An example of the activity questionnaire can be seen in Figure 1b.



(a) (b)

Figure 1. UTRACS Survey (a) Activity-Travel Verification and (b) Activity Questionnaire

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 (*5*), those falling in the lower income categories were oversampled to yield a final income distribution similar to that of Census 2000.

DATA VALIDATION

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 2,160 trips and 2,131 activities was collected from the seniors and on 2,397 trips and 2,371 activities from the younger respondents, totaling 4,557 trips and 4,502 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 (*8*), 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 (*9*). The overall response rate, in terms of persons, was 11.95%, and in terms of households, 11.31%, which is satisfactory for complex two-week internet survey requiring a significant time commitment from respondents. Other long-duration surveys had comparable response rates (*4, 10*). Accordingly to the recommendations in (*8*), the following variables are tested for sample bias: household size, vehicle availability, household income, age, race and gender. Survey values were compared against data from the American Community Survey. For the elderly subset, the RMSE is 56.46%. For the non-elderly, the RMSE is more satisfactory: 32.08%. The sample characteristic that most contributed to the inflation of the RMSE was household income. The geographic distribution of respondents satisfactorily matches that of the study area population.

ACTIVITY PLANNING DATA RESULTS

The results of the UTRACS survey, in terms of important activity participation statistics and activity planning process measures are shown in Tables 1 to 3 below, for *out-of-home activities only*. Table 1 shows several key activity statistics for six different general classes of activities. The statistics include the average total time spent in each activity class per day, the average daily frequency and the average activity duration. Each statistic is shown for the population as a whole, and for key socio-demographic subpopulations. The results show how activity participation varies according to these binary sociodemographic classifications.

TABLE 1. Activity Participation Statistics by Major Socio-demographic Variables

Total Average Daily Duration (in hours)

	All	Employed	Student	< 65	Female	Teleworker	ICT users
Work/School	2.8	2.9	3.5	4.8	3.0	4.1	2.5
Personal/Service	0.6	0.6	0.4	0.3	0.6	0.4	0.5
Household-related	0.2	0.1	0.1	0.2	0.2	0.2	0.2
Discretionary	1.8	1.7	1.8	1.7	1.6	1.7	1.8
Shopping	0.5	0.5	0.3	0.4	0.6	0.3	0.4
Other	0.3	0.4	0.7	0.4	0.4	0.1	0.3
Total	6.2	6.3	6.7	7.8	6.4	6.8	5.7

Average Daily Frequency

	All	Employed	Student	< 65	Female	Teleworker	ICT users
Work/School	0.6	0.7	0.6	1.0	0.7	1.0	0.6
Personal/Service	0.5	0.5	0.6	0.4	0.6	0.3	0.4
Household-related	0.3	0.3	0.4	0.3	0.3	0.3	0.3
Discretionary	0.9	0.9	1.0	0.7	0.9	0.7	0.9
Shopping	0.9	0.9	0.4	0.7	0.9	0.7	0.9
Other	0.4	0.4	0.3	0.3	0.3	0.3	0.4
Total	3.6	3.6	3.3	3.3	3.7	3.4	3.5

Average Activity Duration

	All	Employed	Student	< 65	Female	Teleworker	ICT users
Work/School	4.5	4.5	6.0	5.1	4.3	3.9	4.1
Personal/Service	1.2	1.2	0.7	1.0	1.2	1.1	1.1
Household-related	0.7	0.6	0.2	0.8	0.7	0.7	0.8
Discretionary	1.9	1.9	1.9	2.3	1.8	2.3	1.9
Shopping	0.6	0.5	0.6	0.5	0.6	0.4	0.5
Other	0.9	1.0	2.2	1.5	1.3	0.2	0.9

Table 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.

TABLE 2. Activity and Activity Attribute Plan Horizon Analysis

Activity and Attribute Plan Horizon Distributions

	Activity	Mode	Who-with	Location	Start Time	Duration
Impulsive	24%	18%	20%	24%	34%	57%
Same Day	26%	20%	24%	22%	25%	11%
Same Week	21%	19%	17%	17%	13%	7%
Preplan	9%	8%	8%	8%	6%	4%
Routine	20%	36%	30%	29%	21%	21%
Total[1]	2766	2137	2606	2658	2674	2655

Plan Horizon Correlation Values

	Activity	Mode	Who-with	Location	Start Time	Duration
Activity	1					
Mode	0.47	1				
Who-with	0.72	0.40	1			
Location	0.82	0.42	0.62	1		
Start Time	0.79	0.46	0.60	0.72	1	
Duration	0.54	0.37	0.44	0.49	0.66	1

1. Total activities minus missing/don't know responses and, for mode, observations with no trip.

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 results show that fixity varies, with most attributes evenly split between fixed and flexible decisions, but with much flexibility in the duration choice. The flexibility correlation matrix shows that there is very little correlation between the various flexibility measures.

TABLE 3. Attribute Flexibility Analysis

Attribute Flexibility Distribution

	Mode	Who-With	Location	Start Time	Duration
Flexible	55%	52%	51%	82%	50%
Inflexible	45%	48%	49%	18%	50%

Flexibility Correlation

	Mode	Who-With	Location	Start Time	Duration
Mode	1				
Who-With	0.06	1			
Location	-0.02	-0.10	1		
Start Time	0.09	0.12	-0.07	1	
Duration	0.12	0.13	0.05	-0.02	1

CONCLUSIONS

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. 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. The survey capability of warning respondents about unanswered questions before survey submission contributed to the achievement of a missing value index of only 0.0616. 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. In the same manner, more short trips, both in terms of time and distance, were observed. The analysis of activity rates by various socio-demographic classes shows expected results, such as non-elderly individuals having a much higher activity participation rate than elderly individuals, students participating more than non-students, etc. Two interesting results, however, are that teleworkers exhibit a higher work activity total duration and frequency than employed non-teleworkers, and frequent information and communication technologies (ICT) user had a lower total duration of activities than non-ICT users, most likely due to substitution effects as the analysis is based only on out-of-home activities. Finally, the activity attribute planning results demonstrate the varied nature of activity planning, where some attributes such as mode and location decisions tend to be more routine and the timing attributes tend to be more impulsive, and all of the attributes experience a variety of fixities further constraining the planning.

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