

## An Analysis of Accessibility, Social Interaction, and Activity-Travel Fragmentation in California

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### Project Objective

*Fragmentation* of activities and travel is defined in this project as the sequencing of many short activities and trips that happen in a person's daily schedule. These are combined with other activities and travel that are much longer to form a complete string of episodes and durations of each episode by each individual we observe. Fragmentation in a schedule that is made of a sequence of activities means multiple switching between different activities in a day, e.g., the sequence of: *escorting children to schools—go to work—eat meal with colleagues—run errand—go back to work—go to a social event—go back to work—pick up children from schools—go shopping—return home—escort a child to soccer practice—do some work using mobile technologies—escort child back home—work at home*. This is a pattern of high complexity and fragmentation. Patterns like this lead to increased transport demand because many activities are no longer bound to specific times and specific places, different people need to be escorted in different activity locations, and work can often be done ubiquitously. The usual mode enabling fragmentation and flexibility in scheduling is the private car. However, we do not know if daily patterns with high fragmentation necessarily also entail high use of the private car. In this project, we demonstrate a relatively new method of travel behavior analysis to examine daily patterns in a holistic way and identify *how and why individuals engage in activity-travel fragmentation*.

### Problem Statement

We seek a method that depicts and explains activity sequencing during a day at specific locations, activity and travel durations by type, and their correlation with spatial opportunities as well as social and demographic characteristics. Using *sequence analysis* we examine places visited by a person during a day jointly with the duration of activities at each place, and travel time spent to reach these places. Entire daily sequences of activities and travel are described by an indicator called *Complexity (C(s))* that captures fragmentation in daily activity-travel patterns for each individual in a succinct mathematical way. We study this indicator for households to explore differences and commonalities in couples with and without children. We also develop a taxonomy of nine representative patterns of daily place-time allocation, study their behavioral characteristics, and show their relationship with social and demographic characteristics. We use data from the statewide survey of 2012-2013 called the California Household Travel Survey (CHTS).

### Research Methodology

The sequences we study are time series of 1440 minutes in a day, and each minute is classified in one of the categories: Home, Work, School, Travel, and Other. To develop a taxonomy of nine representative patterns of daily place-time allocation we use cluster analysis on dissimilarities among these sequences. Dissimilarities derived by comparing sequences are stored in a matrix and then using clustering techniques on this dissimilarity matrix we identify a small number of groups of sequences that represent similar time of day activities and travel patterns in our sample. Each of these patterns is characterized by different fragmentation, Travel Time Ratio (TTR defined as the total travel time in a day divided by the sum of the total time in activities outside the home plus the total travel time in a day), and modes of travel used by the survey respondents(modal split). Membership in each of these clusters is

also analyzed to identify how different people in terms of their social and demographic traits use different daily rhythms in their spatio-temporal behavior.

## Results

A statewide taxonomy of nine distinct daily patterns is found using a sample of 12,704 persons from 5,000 households spread throughout California (Figure 1). These include patterns of people staying at home for long periods in a day, people that follow typical daily working schedules and typical school schedules. We also find people that travel for an entire day and people that stay at home in the morning but then travel for the rest of their interview day. We also have two patterns of running errands with very different time of day rhythms. The ninth pattern is by people that spent most of their time in a day at locations that are not home, work, or school and travel for very short time. Each pattern has different travel behavior characteristics, (i.e., time allocated to places, number of trips, modal split, and TTR), and different memberships in terms of gender, age, and day of the week (in addition to the working and/or student status as expected). Household children motivate higher levels of fragmentation and traveling by car. Dwellers in the center of a city have more fragmented schedules but only in a few daily patterns.

In our comparison between men and women that live in the same household we find that in couples with no children, employment status influences fragmentation of activities in such a way that the employed person has a more fragmented schedule regardless of gender. In households with children, women have consistently more fragmented schedules than men regardless of employment status (Figure 2). This further strengthens the household responsibility hypothesis for women who, in addition to working outside the home, also run a variety of errands, and for this reason need to visit multiple places in a day. Driving alone is the preferred mode in the typical and non-typical commuting daily patterns. In addition, Complexity and TTR are significantly different among households living in urban, suburban, exurban, and rural environments within each daily pattern. Accessibility to opportunities was also found to be a significant factor in an application of this new method to the Central Coast region in California.

