Complexity of Travel-Based Multitasking And Its Association To Latent Lifestyles

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Introduction

Autonomous mobility is no longer a dream, and when the technology becomes available for the public use, it is expected to change transportation systems drastically (Manyika et al., 2013; Silberg and Wallace, 2012). A well-panned diffusion of this technology is expected to bring several benefits to the society by improving travel time productivity (Malokin et al., 2019; Wadud et al., 2016), among other benefits (Fagnant and Kockelman, 2015; Harper et al., 2016; Mersky and Samaras, 2016).

The specific activity and or the set of activities being conducted in the vehicle while traveling is typically referred to as the *travel-based multitasking* (Circella et al., 2012; Keseru and Macharis, 2018; Malokin et al., 2019) which is a special case of multitasking as a general concept. As argued by Mokhtarian and Salomon (2001), people might gain a positive utility from their travels, for various reasons. Therefore, travel-based multitasking plays a crucial role in offering a satisfactory travel experience to people during their rides (Circella et al., 2012; Malokin et al., 2019; Singleton, 2018). In this sense, understanding the preferences of travelers in terms of their travel-based multitasking habits could be considered as the key to successfully designing the interior of future AVs and their trims.

A profound literature explores various aspects of travel-based multitasking (Frei et al., 2015; Line et al., 2011; Lyons et al., 2016; Malokin et al., 2019; Mokhtarian et al., 2015; Pawlak et al., 2016; Rasouli and Timmermans, 2014; Zhang and Timmermans, 2010). Yet, very few studies have investigated the association of in-vehicle activities to the individuals' habits and higher-level orientations (i.e., lifestyles).

The present study is set out to analyze the associations between the pattern of activities being conducted while travelling by public transportation, and the higher-level orientations being characterized as: (1) personal attitudes and preferences, (2) habits of travel-based multitasking, as well as (3) the various socio-demographics (e.g., household income) being recognized by the literature of lifestyle research as proxies for the higher-level orientations.

Survey Design

The data used in this study is obtained from a survey recently designed and conducted by a research team of scholars from Argonne National Laboratory, University of Illinois at Chicago, and University of Chicago. Detailed information about design of different parts of the survey, implementation process, and descriptive statistics of the collected data can be found in the authors' previous work (Auld et al., 2018).

The survey was designed as an in-station intercept survey, and the data collection effort covers all major types of transit in the Chicago metropolitan area, including Metra train, CTA rail, Pace bus, and CTA bus. The survey puts together socio-demographics, travel-based multitasking habits, the activity being conducted immediately before (and after) the trip, activities being conducted during the travel, other travel attributes such as travel time, and attitudes towards the transit service in general.

Table 1. Definition and description of in-vehicle activities in the sample

Activity type	Definition of the in-vehicle activity type	Prevalence among transit users (%)
Reading	Conventional reading (excluding reading in a tablet, laptop, cellphone, etc.), with purposes not related to work or school.	73.9%
Technology	Using an electronic device (e.g., smartphone, tablet, or laptop), with purposes not related to work or school.	90.7%
Phone	Talking on the phone, with purposes not related to work or school.	55.8%
Mandatory	All work- or school-related activities.	56.6%
Social	Conventional social activities, excluding checking social media online, talking on phone, work- or school-related activities.	59.8%
Relaxing	Performing activities not related to reading, phone calls, work, school, or socializing, while not using technologies in any form.	82.9%

Methodology

In addition to the detailed descriptive analyses, the list of methods used in this research encompass: (1) principal component analysis (PCA) and graph theory to understand the activity patterns in terms of the activities being usually conducted together as well as the complexity of the combinations, and (2) latent classification discrete choice modelling (Greene and Hensher, 2003) to uncover the latent lifestyle classes underlying the behavior.

Principal Component Analysis

Hidden collinearity relationships within a given dataset of n attributes cause them to share certain amount of information. PCA provides a convenient platform for capturing/using such shared information in order to extract essence of the data, using information from the overall correlation matrix (Han et al., 2011; Robert, 2014).

Graph Theory

First developments of graph theory date back to the well-known contribution of (Euler, 1741) where the author studied possibility of crossing all seven bridges in Kaliningrad, Russia, consecutively and only once. Among more recent outstanding contributions to the field of transportation studies, we can also refer to (Derrible and Kennedy, 2011) where the authors offer a well-structured review of the graph theory literature and discuss prominent concepts, and discuss how the theory could be adopted in the context of transit networks to study different aspects of the complexity of a transit network.

Latent class discrete choice modelling

Greene and Hensher (2003) propose the Latent Class Model (LCM) formulation as an extension of the well-known multinomial logit formulation (McFadden, 1974) that accounts for the heterogeneity across observations by classifying them into latent classes. The general concept of latent modelling, and more specifically, the latent class discrete choice modelling approach has been used extensively in the literature of lifestyle modelling (Salomon and Ben-Akiva, 1983b; Vij et al., 2013).

Results

Technology and Relaxing are the highest probable activities to be conducted for the whole duration of a ride in a *simple* travel-based multitasking (i.e. only one activity is being combined with the travel). In case of a *complex* multitasking, also, reading and technology are the highest probable activities to be chosen as the primary activity, while relaxing and mandatory sit in next positions and rest of the activities are highly unlikely to be the primary focus of riders. Per the results of PCA, conducting a mandatory activity in the vehicle is among the most dominant sources of variation in forming the complexity of transit users' ravel-based multitasking. According to the results of latent lifestyle analysis, people from higher income households and those who prefer transit over other modes because they think it helps them make better use of their time while travelling are more likely to perform mandatory activities.

Conclusion

As a special case of multitasking, travel-based multitasking typically refers to conducting a set of in-vehicle activities while traveling. Travel-based multitasking can be considered as a means for increasing productivity of individuals during the day of travel; thereby, understanding individuals' attitudes and habits with regards to travel-based multitasking could help the designers of the future autonomous vehicles to better meet the needs of their users. Our results indicate the existence of different latent lifestyles groups and its association with the activities being conducted during a specific travel.

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