THE INFLUENCE OF PSYCHOLOGICAL CHARACTERISTICS ON MANAGED LANE USE: A FURTHER EXAMINATION

A Dissertation

by

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ABSTRACT

As managed lane (ML) prevalence increases in the United States of America, it is important to understand travel behavior in ML settings (i.e., lane choices and carpooling decisions). Socio-demographic and trip data, along with travel time and toll, have been commonly used in this endeavor. However, there are some travelers who pay to use the ML despite there being little to no improvement in travel time over the adjacent general purpose lanes (GPLs). This gives rise to the possibility that psychological traits are a greater influence on ML use than even travel time savings for some travelers.

This research examined this issue through a set of largely transportation-framed psychological items. After an initial creation and refining process, 25 psychological items were included in a survey advertised in five ML study areas (Seattle, Salt Lake City (SLC), Los Angeles, Washington, D.C. (DC), and Minneapolis (Minn)). D_b-efficient (DBE) and adaptive random (AR) designs were used to develop the attribute levels for the stated preference (SP) questions. The DBE design resulted in a higher adjusted rho square value and a higher overall percent correctly predicted value for a given model than the AR design; however, the AR design resulted in a higher carpool express lane (CP-EL) alternative percent correctly predicted value for a given model, and less non-trading and lexicographic behavior. In addition to psychological items, trip and demographic questions, and three SP questions were included in the online survey.

Based on mixed logit models created from responses obtained from SLC, Minn, and DC, better models (in terms of adjusted rho squared value and percent correctly

predicted values) were obtained via the creation of psychological item models, when compared to their psychological scale or trip and demographic model counterparts. Likewise, combined models involving psychological items and trip and/or demographic data performed even better. This information may be useful for traffic and revenue estimating firms interested in potentially including psychological items in future ML surveys intended to facilitate better estimation of ML use.

Those who agree that "the coordination involved with carpooling is more hassle than it is worth" had a lower likelihood of selecting the carpool on the general purpose lane (CP-GPL) alternative than the drive alone on the general purpose (DA-GPL) alternative. Likewise, they had a lower likelihood of selecting the CP-EL alternative than the DA-GPL alternative. The same results were found for those who "do not like relying on others for rides." Those who agreed that "Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time" had a higher likelihood of selecting the drive alone on the express lane (DA-EL) alternative than the DA-GPL alternative. Respondents who said that "When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price" had a higher likelihood of selecting the DA-GPL alternative than the CP-EL alternative, and had a higher likelihood of selecting the DA-EL alternative than the DA-GPL alternative. The opposite was found for those who "cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time". Those who indicated that "I only choose to use the express lane if the general purpose lanes seem crowded" had a lower likelihood of selecting the DA-EL alternative than the DA-GPL alternative.

DEDICATION

To my husband, Nathan Green, and my parents, Bryan and Debbie Larsen.

Thank you for your unfailing love and support.

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NOMENCLATURE

ANOVA	Analysis of Variance
AR	Adaptive Random
ASC	Alternative Specific Constant
ATCON	Scale associated with the Analytical Tendency in Decision Making Process Construct
CFA	Confirmatory Factor Analysis
CP-EL	Carpool on the Express Lane
CP-GPL	Carpool on the General Purpose Lane
CP-ML	Carpool on the Managed Lane
CSDCON	Scale associated with the Control of Situation and Destiny Construct
DA-EL	Drive Alone on the Express Lane
DA-GPL	Drive Alone on the General Purpose Lane
DA-ML	Drive Alone on the Managed Lane
DAS	Driving Anger Scale
DBE	D_b-Efficient
DC	Washington, D.C.
DOF	Degrees of Freedom
DOT	Department of Transportation
EFA	Exploratory Factor Analysis
EL	Express Lane
FHWA	Federal Highway Administration
GPL	General Purpose Lane

HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
IID	Independent and Identically Distributed
IGT	Iowa Gambling Task
LA	Los Angeles
Minn	Minneapolis
ML	Managed Lane
MMNL	Mixed Multinomial Logit
MNL	Multinomial Logit
mph	Miles per Hour
PPP	Public-Private Partnership
ROCON	Scale associated with the Reliance on Others Construct
RP	Revealed Preference
SLC	Salt Lake City
SOV	Single Occupancy Vehicle
SP	Stated Preference
SP1	Stated Preference Question 1
SP2	Stated Preference Question 2
SP3	Stated Preference Question 3
SPA	Stated Preference Question response same across all three stated preference questions
SPSS	Statistical Package for the Social Sciences
SWUTC	Southwest University Transportation Center

TRCON	Scale associated with the Tendency to Take Risks Construct
UTCM	University Transportation Center for Mobility
VOT	Value of Time
VTTS	Value of Travel Time Savings

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1. INTRODUCTION

Managed lanes (MLs) can be viewed as a tool to more effectively utilize roadway capacity. These are freeway lanes that are managed in order to provide a high level of service. Although the ML concept is a relatively new idea in the United States of America (USA), dozens of states are already implementing some form of MLs, with plans for more MLs underway. Different forms of MLs exist, including high occupancy vehicle (HOV) lanes and high occupancy toll (HOT) lanes. Each form of ML has its own criteria for who can utilize it (often based on number of vehicle occupants) and at what cost (i.e., for free or for a toll) (Collier and Goodin 2004). The criteria for ML use may evolve over the course of a roadway's life to better address changing needs; or in the short-term, during different times of the day to deal effectively with varying levels of congestion.

Consideration of MLs and their effect on travelers has spurred numerous research studies addressing topics ranging from ML equity (Weinstein and Sciara 2004), to people's reactions to MLs (Burris et al., 2007), to ML effectiveness (Kwon and Varaiya 2008). One fundamental question linked to all of these issues is the question of, "Who uses MLs, and why?" Socio-demographic characteristics of travelers are important but are certainly not the only individual differences that could be of interest in better understanding travel behavior on MLs. An avenue of research that has received minimal attention to this point is considering traveler personality traits and how psychological characteristics are related to decision making in the context of ML use (i.e., lane choice and/or carpooling decisions). This is an interesting topic that warrants further investigation in light of the fact that some drivers choose the ML over the general purpose lane (GPL), even when the speeds on both roadway types are comparable. While this may partially be a reflection of drivers' willingness to pay for travel time reliability (Burris, Nelson, Kelly, Gupta, and Cho 2012), it is possible that the psychological characteristics of travelers also play a role.

Malone describes a phenomenon seen on I-95 in Miami, where sometimes the ML gets crowded despite the toll being high. Engineers hypothesize that this may be the result of travelers assuming that paying a higher toll should be associated with higher travel time savings (Malone February 28, 2014). Paulo Pezzato, in referring to what Wes Friese (the former director of HCTRA) theorized, mentions that there may be a group of people who choose to pay to use the ML just because they can—despite the fact that it may not be beneficial in saving them time. They may view it as a sign of prestige (Pezzotta March 3, 2014). These findings point to the possibility that psychological characteristics play a role in the decisions travelers make in ML settings, especially with regard to lane choice. However, the extent to which the psychological characteristics of travelers can be useful in predicting ML use decisions is not known, and thus requires further investigation.

2. PROBLEM STATEMENT

Prior to elaborating on the problem statement, a few basic terms used throughout the present research need to be defined.

2.1 Some Basic Definitions

An understanding of the terms “item”, “scale”, and “construct” are critical to understanding the present research. An item can be thought of as a statement included within a survey about which a respondent is asked to respond. In the case of the present study, and the preliminary work of Burris, Arthur, Devarasetty, McDonald, and Munoz (2012a) and Green and Burris (2014), respondents responded to items using a Likert scale ranging from 1-9. For example, for PSY1, “It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time”, respondents were asked to indicate the extent to which they agreed with this statement on a 1-9 point scale. In this case, if they responded with a “7”, it meant that they “somewhat agree” with this statement. Twenty-one of the items were answered using a magnitude Likert scale and four of the items were answered using a frequency scale. Greater detail associated with the Likert scales used is provided in Section 6.2.

Seventeen of the 25 items included in the present study were also analyzed as part of a scale. A scale is a group of related items. In other words, it is thought that these group of items, or scale, all relate to some idea, trait, concept, or attribute. In the case of the present research, psychological attributes were of particular interest. Crocker and Algina explain how psychological attributes are an example of a construct (2008, p. 4):

> Psychological attributes are *constructs*. They are hypothetical concepts—products of the informed scientific imagination of social scientists who attempt to develop theories for explaining human behavior. The existence of such constructs can never be absolutely confirmed. Thus the degree to which any psychological construct characterizes an individual can only be inferred from observations of his or her behavior (p. 4).

To understand and measure a construct or attribute, one develops a scale or measurement tool, which consists of items. Further discussion on scales and constructs is provided in Section 4.2.1.

2.2 Need for Further Research

Burris, et al. (2012a) undertook a preliminary examination that laid the groundwork for investigating the psychology behind ML use. In this study, participants who had recently traveled along a corridor containing a ML completed a survey which measured their personality along five constructs, specifically: Conscientiousness, General Locus of Control, Personal Need for Structure, Risk Tolerance, and Driving Risk Perceptions and Driving Style (consisting of the subscales of Driving Risk Perceptions, Careful Driving Style Composite, and Risky Driving Style). Respondents from the cities of San Diego, Denver, Miami, and Seattle were targeted for inclusion in the sample (although data from Seattle were not used in the analysis because only three responses were received). As part of the survey, each respondent was presented with three stated preference (SP) questions. The SP questions were set in the context of their most recent trip on a local roadway that had MLs. The following four alternatives were included in each SP question:

- Drive Alone on the General Purpose Lane (DA-GPL)
- Carpool on the General Purpose Lane (CP-GPL)
- Drive Alone on the Managed Lane (DA-ML)
- Carpool on the Managed Lane (CP-ML)

Based on the SP responses, mixed logit models predicting a traveler's selection of the above alternatives were developed. The models included the scales associated with psychological constructs as independent variables. However, these preliminary models generally did not yield significant findings relative to the psychological constructs. Nevertheless, the availability of this dataset allowed for the possibility of more extensive research in this area.

Green and Burris (2014) took a more disaggregated approach to analyzing the dataset by examining the measures at the item level with the objective of determining if any of the psychological items, at a disaggregate level, could be used to better understand travel behavior on MLs. A base model consisting of alternative specific constants (ASCs), travel time, toll, and common socioeconomic variables was compared to similar models containing additional items corresponding to individual psychological items used by M. Burris et al. (2012) . The adjusted rho square value and percent correctly predicted value by mode (i.e., DA-GPL, CP-GPL, DA-ML, CP-ML) were considered in comparing models. Green and Burris's (2014) results indicated that some psychological items meaningfully contributed to improvements in models used to predict ML choice. While informative in and of themselves, more than anything, the psychological items that contributed to improved or reasonable models were useful in guiding the creation of additional psychological items and measures to further investigate the role of psychological characteristics in ML use.

One of the limitations associated with the dataset used in both Burris et al. (2012) and Green and Burris (2014) is that because of the length of the survey and the resistance of participating sites to having such a lengthy survey, each participant completed only a subset of the psychological items. Specifically, eighteen different blocks, each containing three of the six psychological constructs, were created and each survey respondent was randomly assigned to one of the blocks—meaning that each person completed approximately half of the psychological items. This creates sample size limitations when constructing models within mode choice modeling because only respondents with responses for every key parameter included in the model are included within the sample used in creating the model. In other words, blocking of this type can lead to a significantly decreased sample size during model creation, which can ultimately make it difficult to place confidence in (or find meaningful significance in) the resulting models. Reducing the number of items so that all respondents have the opportunity to respond to all of the psychological items will result in more data being available for modeling. Consequently, the present study addressed this weakness through the construction of a survey with fewer psychological items, and thus made it practically feasible to administer all the items to all the participants.

Given the fact that the items were either created as part of this research effort, or were taken from existing scales to be considered as individual items, the results can no longer be compared against established psychological scales. Thus, whereas the measures used here are not argued to have unquestionable construct validity from a psychological psychometric perspective, the results are nevertheless meaningful and informative from an engineering perspective because we are interested in better understanding transportation choices and how psychological characteristics are related to travelers' decisions. In an effort to address these varying perspectives, the psychological items included in the survey were analyzed not only at the item level, but were also created with the possibility of establishing new scales based on the largely transportation-based psychological items of interest. The validity of these potential scales was considered through the item development process with the implementation of a substantive validity study followed by an empirical validation (via factor analysis) of the substantive validity results. Modeling with the psychological data obtained from the survey was performed at both the aggregate and disaggregate level to assess whether individual items or items in the more aggregate scale form are useful in understanding travel behavior on MLs.

3. RESEARCH OBJECTIVES

The objective of this research was to better understand travel behavior. Specifically, the extent to which psychological characteristics—at both the construct (scale) and item level—are useful in predicting ML travel behavior were investigated. The research addresses limitations and gaps within the existing body of knowledge.

The overarching objective of better understanding travel behavior was addressed by accomplishing several key sub-objectives. The first goal was to create additional psychological items, largely framed in a transportation context, for use in future modeling. Then the objective shifted to refining the psychological items based on reliability, validity, and interest for inclusion in a survey administered in five cities (Seattle, Salt Lake City (SLC), Los Angeles (LA), Washington, D.C. (DC), and Minneapolis (Minn)) with MLs. This was followed by the design, set-up, and execution of the survey. Preliminary steps ultimately led to the successful creation of discrete choice models to assess the extent to which psychological items, and/or the newly developed scales, may be used in understanding travel behavior on MLs. Consideration of the effect of income on the VTTS was also of special interest. Another intent of this research was to assess the impact of SP experimental design on model outcomes (specifically considering efficient and adaptive designs).

It should be noted that from a psychological psychometric perspective, individual items are of little interest because a stand-alone item cannot adequately encompass an idea or trait that a construct may be attempting to represent. Thus, psychologists (and other behavioral scientists) do not investigate and examine phenomena at the item-level.

That being said, this may be less of a concern in the context of discrete choice modeling in a transportation framework. From a transportation engineering and planning perspective, individual psychological items may be of interest. Discrete choice modeling relies heavily on the inclusion of different items—be they socio-demographic, trip characteristics, or psychological items. Thus, while the present study included an effort to develop items that load onto constructs from a construct validity perspective (a psychologist's perspective), individual items were also utilized in the discrete choice modeling process, and used in drawing conclusions that may be helpful in better understanding decisions made in ML settings (i.e., lane choice and/or carpooling decisions).

4. LITERATURE REVIEW

There are a number of key topics that are critical to understand in order to gain a firm grasp of the research at hand, and an understanding of how this research effort contributes to the existing body of knowledge. This section contains a review of the topics of MLs, scale construction, psychology in the realm of transportation, SP questions, and discrete choice/logit models.

4.1 Managed Lanes

Given that this research centers on decisions made in ML settings (i.e., lane choice and carpooling decisions), it is important that an overview of MLs be provided. First, an overview of MLs in the USA is presented. Next, a description of various types of MLs is given. This is followed by a summary of ML research found in the literature.

4.1.1 Brief Overview of MLs in the USA

MLs are a relatively new concept in the USA. As chronicled in a technical memorandum associated with the Charlotte Region HOV/HOT/Managed Lanes Analysis, the first HOV lanes began mostly as bus lanes, or the beginning of bus rapid transit, in the 1960s. When a bus strike occurred in LA in 1976, the idea to allow carpools to use the lanes that were once just for buses was put into practice. HOT lanes, on the other hand, are an even more recent idea that did not emerge in the USA until the mid-1990s. The ability to electronically collect tolls with transponders helped HOT lanes emerge as a more feasible option. Along with providing some of the history of ML in the USA, the authors of the technical memorandum add that ML funding generally consists of money from the federal government that matches state or local input. They also warn against simply converting an existing GPL to a ML, as this can create more congestion problems than it fixes (Experiences with Managed Lanes in the USA 2007).

Similar sentiments are expressed within a ML primer created by the Federal Highway Administration (FHWA) (2008) They provide an overview of different ML issues and best practices. They state that, “Managed Lanes are defined as a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions” (Federal Highway Administration 2008, p. 4). Three management strategies, with the potential for combining the strategies, can be used in ML operation; namely pricing, vehicle eligibility, and access control. One strategy that can help with addressing ML issues in a timely manner is termed active management—wherein, the current conditions along a ML corridor are monitored and the parameters associated with using a ML are altered to address current needs. Technology is noted as being important to successful implementation of MLs, along with the need for enforcement. The ability to form public-private partnerships (PPPs) is cited as a way to help finance MLs. The SR91 express lanes (ELs) was one of the first MLs to successfully implement a PPP. Within the primer, it is also noted that effectively reaching out to the public to explain what MLs are and their potential benefits is important for success. Also, from a planning standpoint, it is important to incorporate ML plans into the broader regional plan (Federal Highway Administration 2008).

4.1.2 MLs in Their Various Forms

As mentioned, MLs exist in various forms. The two most prevalent types of MLs are HOV lanes and HOT lanes. A brief description highlighting some of the distinguishing features of these two types of MLs is provided within this subsection.

4.1.2.1 High Occupancy Vehicle (HOV) Lanes

As the name implies, HOV lanes operate on the concept of vehicle occupancy. Vehicles meeting the minimum occupancy threshold value are generally permitted to use the HOV lane (along with certain types of vehicles—i.e., emergency vehicles, motorcycles, etc.) at no cost. Typical cut-off values are 2+ persons or 3+ persons. The idea is that those who carpool will receive a benefit—usually in decreased travel time—for carpooling. However, critics argue that many carpools are simply "family pools" (or "fampools"), consisting of family members who carpool out of necessity (Li et al., 2007). Additionally, there are times when the HOV lane is under-utilized; thus, creating an inefficient method to address congestion issues that may be prevalent along the adjacent GPLs. This is one of the issues that the HOT lane concept addresses, as discussed in greater detail in the next subsection.

4.1.2.2 High Occupancy Toll (HOT) Lanes

HOT lanes build on the HOV lanes concept. However, unlike HOV lanes that limit access strictly by occupancy or vehicle type requirements, HOT lanes add another dimension by allowing travelers not meeting the specified requirements to travel in the lane for a fee. In other words, those meeting the requirements normally associated with an HOV lane are allowed to use the HOT lane for free or a reduced price, while others can pay to use the HOT lane. Unlike a toll road, HOT lanes are accompanied by adjacent GPLs, giving travelers the option to travel along the same corridor without paying a toll, irrespective of their type of vehicle or carpooling status. HOT lanes are sometimes referred to as ELs.

HOT lanes are often transformed from existing HOV lanes, and sometimes the requirements associated with a HOT lane are adjusted to meet changing needs. For example, when the SR91 ELs were first opened as HOT lanes, HOV 3+ vehicles were permitted to use the ELs for free. Later, the policy was changed so that HOV 3+ users were charged half of the toll of other EL users (Poole and Orski, 1994). There is the potential to implement toll lanes specifically for trucks. However, this concept has been difficult to implement because it requires two truck toll lanes be created in each direction—allowing for trucks to pass each other (Experiences with Managed Lanes in the USA 2007).

Poole and Orksi (1994) clearly describe the benefits generally associated with HOT lanes. HOT lane benefits are often most distinct when HOV lanes are either underutilized because of the restrictions placed on its use or too congested because the requirements for its use are too loose. HOT lanes are an example of value-pricing. As explained by Poole, "The intent of value pricing is not to discourage drivers from using congested facilities but to offer them—for a fee—the option of alternative road facilities that provide a higher level of service" (p. 10). They list the undermining of the HOV lane concept, environmental opposition, and equity issues as three of the greatest concerns when implementing a HOT lane (Poole and Orski, 1994). However, the authors rebut each of these concerns by stating that HOT lanes benefit both users and non-users, better flowing traffic actually reduces emissions when compared to stop-and-go-traffic, and drivers from all income levels use HOT lanes when they want the assurance of an on-time trip (Poole and Orski, 1994).

Often, the toll rate associated with HOT lanes changes depending on the time of day or congestion level. This is known as congestion pricing, and enables transportation professionals to more efficiently manage the HOT lane and ensure that a certain minimum speed is met. This dynamic approach provides more control and allows inefficiencies in HOT lane use to be resolved more quickly.

4.1.3 Research on MLs

Related to the debate over whether HOV lanes or HOT lanes are more desirable is the issue of carpooling. Does the type of ML have an impact on carpooling? Li et al. (2007) analyzed the question of who carpools using survey data from the Dallas-Fort Worth and Houston areas. Only a small portion of carpools were found to be formed in response to HOV policies. However, the number one reason cited for carpooling was the ability to use the HOV lane. Thus, the implication of HOV policies may be complex (Li et al., 2007).

Teal (1987) also considered issues related to carpooling. For his analysis, he specifically defines a carpooler as "anyone who shares transportation to work in a private vehicle with another worker" (p. 206). He notes that many factors contribute toward carpooling levels, including vehicle availability, trip length, and costs associated with commuting. He also states, as do other studies (Li et al., 2007), that carpools often consist of household members—which has different implications than when co-workers carpool. In fact, according to the 1977-78 Nationwide Personal Transportation Survey, 40% of carpools were household carpools (Teal 1987). More recently, Burris and Figueroa (2006) found that of those they surveyed on two HOT lanes in the Houston area "the carpool passengers were predominantly (over 60% for each group) a family member" (Burris and Figueroa 2006, p. 109). While the definition of carpooling may vary from study to study, these findings all point to the need to further consider the implications of "fampooling" on how carpooling on MLs is assessed and handled.

Li (2001) used data from 759 cases along SR91 in California to examine the factors that impact a person's choice to use the HOT lane. Li limited the study to the peak period, to enable the focus of the research to be on other variables. Li (2001) states that, "This study hypothesizes that under the traffic conditions of rush hour periods and given travel alternatives, three categories of factors determine people's decision to use HOT lanes: travelers' travel characteristics, financial capability, and demographic characteristics" (p. 64). Within our study, we plan to assess if a fourth category—namely traveler psychological characteristics—also plays a role in the decision to use HOT lanes, or more broadly, MLs. Li found that "people who drive home from work are 1.8 times as likely to use HOT lanes as those who drive to work from home" (p. 71). While this may seem counter-intuitive, possible explanations exist, including people valuing time with their family and more congestion occurring along SR91 in the afternoon than in the morning (Li 2001).

Golob used structural equation modeling to study the association between EL choices and attitude towards having the I-15 HOV lanes in San Diego changed to a HOT lane system, as was done as part of a Congestion Pricing Program. The four main questions of interest to Golob were the following (Golob 2001):

- Approval level of whether solo drivers should be allowed to pay to use HOV lanes
- Perceived fairness of FasTrak to carpoolers
- Perceived effectiveness of FastTrak in reducing overall congestion on I-15
- Perceived safety advantage of traveling in the carpool lanes.

Golob found that behavior seemed to have a causal effect on attitude in some cases, but the reverse was not found to be true. Specifically, the models seemed to indicate that FasTrak use was positively associated with approval of the HOT lane policy, as well as safety advantages of the ELs. Carpool use was associated with a negative attitude concerning FasTrak to carpoolers, a negative perception of the effectiveness of the ELs, and a positive perception of the safety advantages of ELs (Golob 2001).

Devarasetty, Burris, and Shaw (2012) studied whether respondents to a previous SP survey regarding MLs planned for the Katy Freeway actually used the ML as they said they would. A total of 869 respondents were assumed to have responded to both the SP survey in 2008 and the follow-up survey performed in 2010. Based on comparisons made using this sample, it was found that in 2010, “66.3% of those respondents had used MLs. This finding compares favorably with the percentage who in 2008 predicted that they would (42.9%) or might (34.5%) use MLs once they opened” (p. 62).

Burris and Pendyala (2002) researched what factors were associated with travelers in response to variable tolling in Lee County, Florida. As is common within ML research, they specifically considered socio-economic and commute characteristics within their models. Among the socio-economic variables considered were age, employment status, gender, household type, education, and income. Commute characteristics considered included trip purpose, flexibility in time of travel, and flextime availability. The authors found that, "flextime availability at the traveler's place of employment and being retired both increased the likelihood of the driver altering his or her time of travel to obtain the toll discount. Conversely, having a high household income or being on a commute trip decreased the likelihood" (p. 250). While the present research includes similar common variables related to socio-economics and trip type, psychological items and measures were also considered in modeling.

4.2 Scale Construction

The following section describes important terms and issues associated with scale construction. First, a description of what is meant by the term "scale" is provided. Next, the pivotal concepts of reliability and validity are presented. Then, factor analysis is discussed as a psychometric and item reduction technique, and various issues to consider in scale design are described. Lastly, various methods of scale construction described in the literature are highlighted.

4.2.1 What Is a Scale?

While a brief explanation of what a scale is was provided in Section 2.1, an additional definition and an example of a scale is provided here. As described by

DeVellis (2012), “Measurement instruments that are collections of items combined into a composite score and intended to reveal levels of theoretical variables not readily observable by direct means are often referred to as *scales*” (p. 11). For example, as briefly mentioned previously, research performed by Burris et al. (2012a) included, among others, a scale measuring conscientiousness—where conscientiousness is the construct. Thus, the items included within this scale all relate to some aspect of conscientiousness.

4.2.2 Reliability and Validity

There are two general psychometric properties of measurement tools that are considered in developing and evaluating a scale; namely reliability and validity. As the name implies, reliability is an indicator of (under the assumption that the construction is temporarily stable) the consistency of scores and measures the presence of measurement error in scores. It is important to note that reliability is a property of scores, not an imbued property of a test. Thus, the same test (or survey) given multiple times may lead to different reliabilities each time it is administered (Thompson 2003). Reliability generally increases as the number of items in a scale increases. Higher reliability created by developing a narrower scale with redundant items may not be advisable (Simms 2008).

Three common facets of reliability are internal consistency, test-retest, and alternate (or equivalent) form reliability (DeCoster 2000; Thompson 2003). Unlike test-retest and alternate form reliabilities, internal consistency estimates can be obtained with a single administration of the measure making it the most widely used and reported reliability estimate, with the Cronbach alpha being the most commonly reported indicator of internal consistency. Internal consistency reliability is the type considered in the present research, and is discussed further in Section 5.5.1.

Validity is the appropriateness of inferences drawn from test scores. Note that, “Score reliability clearly is a necessary but not sufficient condition for score validity” (Thompson 2003, p. 6). In other words, if scale scores are unreliable, then the question of validity becomes less meaningful. Like reliability, there are several approaches to obtaining evidence to support or demonstrate the validity of test scores with some of the most widely used approaches being criterion-related, construct-related, and content-related validity sources of validity evidence.

The present study implements a substantive validity study which is a specific approach to obtaining content-related validity evidence and is also considered to be a precursor to establishing the construct-related validity of scores. Hence, substantive validity is similar to construct-related validity, except that the focus is more on the individual items, rather than the sgocale as a whole (Anderson and Gerbing 1991; Holden and Jackson 1979). According to Anderson and Gerbing (1991), “Put simply, measures that do not have adequate substantive validity cannot have adequate construct validity” (p. 732). Holden and Jackson (1979), state that, “Items possess substantive validity to the degree to which they are theoretically linked with the relevant underlying dimension” (p. 460).

Anderson and Gerbing (1991) developed two coefficients that can be used in assessing substantive validity. The first is termed the proportion of substantive agreement and is the "proportion of respondents who assign an item to its intended construct" (p. 734). It ranges from 0.0 to 1.0, with 1.0 being associated with higher substantive validity. The second is the substantive-validity coefficient and "reflects the extent to which respondents assign an item to its posited construct more than to any other construct" (p. 734). Substantive-validity coefficient values can range from -1.0 to 1.0. Values close to 1.0 and -1.0 both indicate substantive validity, though values near -1.0 are an indication that the substantive validity is centered on a different construct than the one being considered (Anderson and Gerbing 1991). The equation used to calculate the substantive-validity coefficient is provided in Equation (1) (Anderson and Gerbing 1991).

$$c_{sv} = \frac{n_c - n_o}{N} \qquad (1)$$

where

c_{sv}=substantive-valididty coefficient

n_c=number of respondents assigning an item to its posited construct (in the case of the present study, this was taken to be the number of respondents assigning an item to the most frequently selected construct based on the Item Sort Form responses, discussed further in Section 5.3)

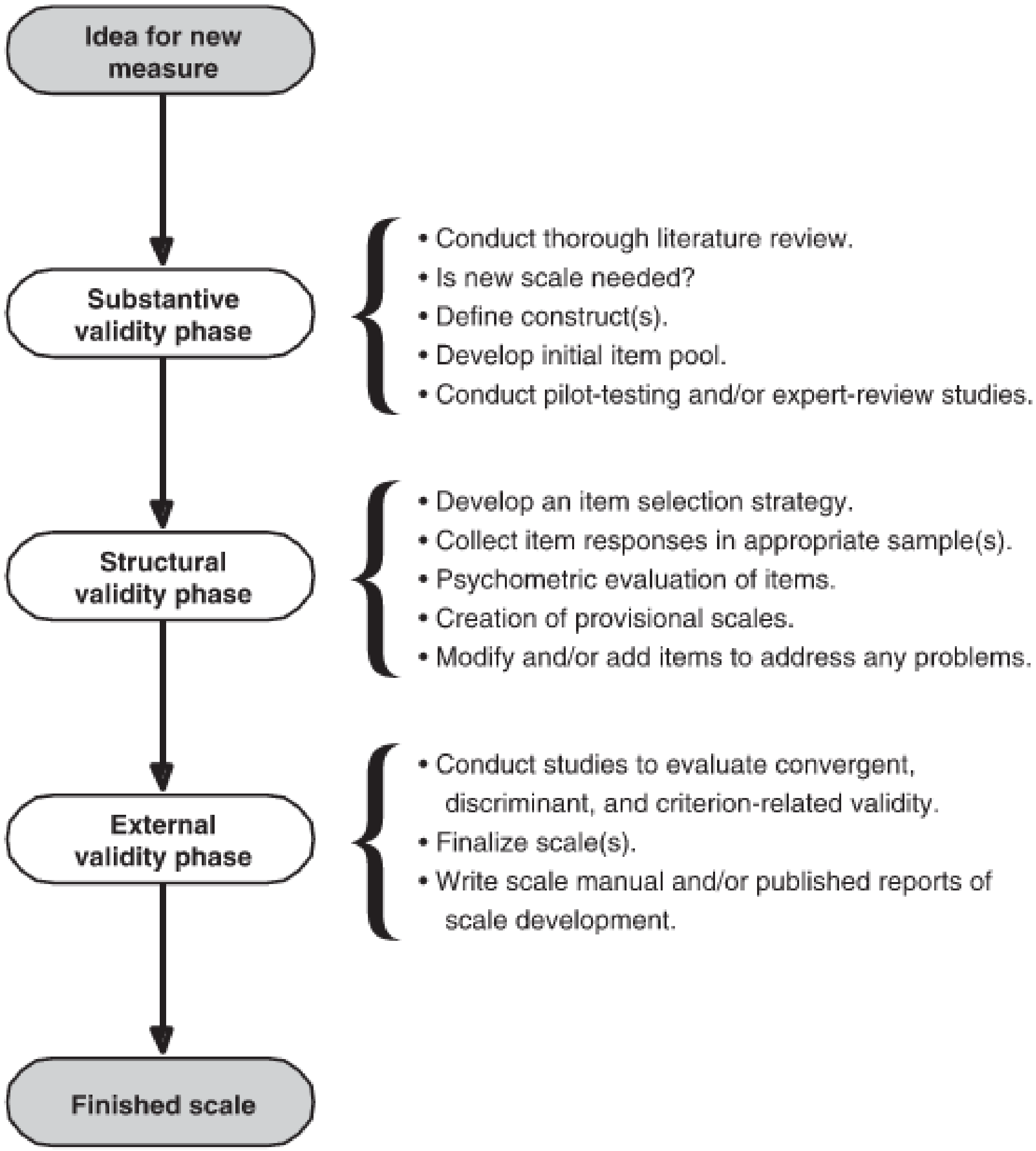
n_o=highest number of assignments of the item to any other construct in the set

N=total number of respondents

One of the benefits of substantive validity testing is it forces researchers to attempt to define the constructs prior to collecting actual survey data (Anderson and Gerbing 1991). Substantive validity is generally established by responses obtained from either experts or people who are representative of the population that will eventually be sampled (Anderson and Gerbing 1991). Prior to being finalized, the psychological items used within the present research effort were sorted into constructs by a sample of 21 respondents for 42 of the items and 20 respondents for one of the items. The proportion of substantive agreement and the substantive-validity coefficient were calculated. This allowed for substantive validity to be considered prior to finalizing the survey, although the level of familiarity with ML varied across the respondents used for the item sort. Adjustments were made based on the substantive validity results prior to finalizing the psychological items to be included in the final survey. See Appendix A for the Item Sort Form.

4.2.3 Methods of Scale Creation

Scale creation is a popular topic within the field of psychology and several theories on scale construction exist. The creation of a scale is a formidable task, requiring a scale developer to thoroughly think through a number of issues to ultimately create a good scale. Within the literature, there are a number of scale construction methods outlined—with a great deal of overlap occurring from method to method. Simms states that, “Methods of scale construction usually are organized into three mutually exclusive groups or strategies: (i) rational-theoretical approaches (ii) empirical criterion keying, and (iii) factor-analytic and internal consistency methods” (Simms 2008, p. 415). While Simms states that these approaches are mutually exclusive, ideally, one would employ all three methods in the scale creation process. The first of these methods—rational-theoretical approach—is generally simple. Essentially, the researcher formulates questions he/she thinks may be good. However, a weakness of this method is that it may result in incomplete constructs (Simms 2008). The second method of empirical criterion keying seeks to develop questions that have the "ability to discriminate between individuals from two groups of interest" (Simms 2008, p. 415). Simms gives the example of questions that yield different responses for normal and depressed individuals, regardless of what the question itself is about (Simms 2008). While this approach will generally produce adequate convergent validity, it may result in questions that lack a theoretical basis; making it difficult to draw useful conclusions because the items included lack focus and meaning from a practical standpoint (Simms 2008). The third category of the factor-analytic and internal consistency method attempts to "identify relatively homogenous scales that demonstrate good discriminant validity" (Simms 2008, p. 416). However, caution should be taken with this approach that the resulting construct is not too narrowly defined for what the construct is trying to measure (Simms 2008). Within Simm's paper, he provides a summary flowchart that summarizes a model, produced by Loevinger in 1957, that outlines one theory of how scales should be constructed, shown in Figure 1.



Source: Simms 2008, p. 417

Figure 1. Flowchart of scale construction.

The scale construction process followed in this research is a mixture of the first and third groups described by Simms. These approaches are not necessarily mutually exclusive. Indeed, ideally, one would employ/use all three. The present research method is related to the rational-theoretical approach in that items thought to be good were developed, although the items development largely stemmed from psychological items that showed promise in Green and Burris (2014). The present research method is also related to the factor-analytic and internal consistency method in that we attempted to group the items into potential constructs prior to undertaking the substantive validity study. Based on the substantive validity results, as well as factor analysis performed prior to finalizing the items, scales of interest were identified, conceptualized, and finalized. The level of detail expressed by Loevinger (1957) in was not employed in this research, largely due to time constraints and that the focus of the present study is ultimately on better understanding travel behavior (not the scale development process).

Hunter and Brinkworth (2011) describe a method that can be used in developing a valid scale. They specifically focus on steps that can be taken early in the scale development process even prior to pilot testing, to help ensure that a good, valid scale is created. The six steps they recommend to follow include the following:

1-Conducting a thorough **search of the literature** to determine what related scales already exist and how the scale in question will contribute new information.

2-Performing **interviews with focus groups** that represent the type of population that will eventually be surveyed.

3-**Synthesizing the literature review and focus group results** to ensure that the results of each are in line with each other.

4-Developing an **initial pool of items**.

5-Having **experts**, largely from the academic field, **validate** the items by asking them to match items to constructs and giving input on things they feel are confusing or aspects that need to be addressed.

6-Performing **cognitive pretesting**, which involves asking potential respondents to rephrase items in their own words and think through their thought process out loud as they take the survey.

After these six steps have been implemented, a pilot test can then be performed (Gehlbach and Brinkworth 2011).

In the scale development efforts associated with the present research, all of the steps recommended by Gehlbach and Brinkworth were not followed, largely because of limited time and resources. A literature review encompassing some existing, related scales was performed, though the review was by no means extensive to the point of being able to conclusively indicate gaps in the literature that the new scales, developed as part of this research effort, addressed. An initial pool of items was developed, the validity of the items was considered by performing a substantive validity study, and some feedback on the items was solicited. However, the validation and refinement process was performed using data obtained from a convenienced lay sample of individuals with a wide and varied knowledge of scales, who were not all experts. Interviews with focus groups, subsequent synthesis of focus group results and the literature, and cognitive pretesting were not performed. While a more in-depth approach to scale development may be useful, the approach followed enabled informative conclusions to be drawn germane to better understanding travel behavior on MLs. However, further efforts in the scale development process would likely have led to more interesting and applicable results (from a psychology perspective) being obtained related to the psychological scale results.

4.2.4 Factor Analysis

Factor analysis is a common tool used in scale construction. It allows researchers to explore and/or confirm the relationship between responses to survey items and determine groups of items that may work well together in forming a scale, which may ultimately be used to better understand a construct. According to Thompson (2004), there are three main purposes of factor analysis; namely to "inform evaluations of score validity" (p. 4), "develop theory regarding the nature of constructs" (p. 5), and to "summarize relationships in the form of a more parsimonious set of factor scores that can then be used in subsequent analysis" (p. 5).

There are two main branches of factor analysis; namely exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA does not require that researches have preconceived ideas about what factors or constructs may exist and how items are related to each other. CFA, on the other hand, stems from theories about factors and constructs, and involves supporting or rejecting those theories (Thompson 2004). Within this research, a series of EFAs were performed using data obtained from the Paper Survey. Based on responses obtained relative to the psychological and SP questions, Cronbach's alpha was calculated in assessing the reliability associated with each psychological scale when various items were included. The results of the series of EFAs, and a Cronbach's alpha analysis, helped guide the decision of which items to include, change, or add in developing the final list of psychological items for the survey.

Reise, Waller, and Comrey (2000) discuss issues to consider in EFA and scale refinement. They mention that it is better to have too many items prior to initial tests of the items, than too few. Additionally, they note that although there is not a standard minimum sample size, it is important that the sample contain some heterogeneity so that you can draw meaningful conclusions from the results. In the present research effort, it would not have been useful to include a psychological item in discrete choice modeling wherein all of the respondents had the same response (i.e., all respondents selected "9-Strongly Agree") because it would not have pointed toward potential differences in responses across those respondents selecting the various mode alternatives. For further details on methods used to determine which items, scales and constructs were considered in the survey associated with the present study, refer to the methodology discussed in Chapter 5.

4.3 Psychology in Transportation Settings

Although the psychology behind ML use has not been extensively studied, psychology within the broader framework of transportation has been studied in various forms. Within this section, an overview of some of this research is provided.

4.3.1 Psychology in Transportation Studies

The focus of several relevant studies within the literature is on different personality traits and their association with traffic crashes or violations. One of the traits researched is risk. By performing a meta-analysis, Jonah (1986) researched the hypothesis that younger drivers (those 16-25 years-old) are more likely to be involved in traffic accidents because they are more likely to take driving risks. This hypothesis was confirmed. Though the literature is mixed, some of the research indicates higher levels of impaired driving and lower level of seat belt use are associated with younger drivers (with slightly different "younger driver" age ranges used for different research). Jonah suggests that differences in risk-taking may be related to differences in risk perception and risk-utility. Jonah also reports that, "There is growing evidence which suggests that the same people who perform one risky driving behaviour also perform other risky behaviours and that this risk propensity is related to accident involvement" (p. 262).

Another trait mentioned in the literature is extraversion. Lev et al. (2008) compared an Israeli group of 51 traffic offenders to a control group of 36 individuals who had not had a traffic offense in the last five years. Both groups were administered the Iowa Gambling Task (IGT), along with a "big five" personality measure. Within the IGT, each respondent is asked to select cards one-at-time from among four decks; making 100 choices in total. Before the game starts, it is explained to them that in order to win money, they should avoid certain decks that are worse than others. Those in the traffic offenders group were significantly more likely to be extraverted, which may be partially linked to risk-taking tendencies in certain situations. Traffic offenders were also less likely to make advantageous decisions in the IGT than the control group. Based on an analysis using the Expectancy Valence cognitive model, the authors believe that this may be a reflection of the traffic offenders (who again, as a group, were significantly more likely to be extraverted that the control group) weighing gains more heavily than losses (Lev et al., 2008) .

Two additional examples of meta-analyses (in addition to the example already cited from Jonah) performed within the area of driver characteristics were by Arthur, Barrett, and Alexander (1991) and Clarke and Robertson (2005). The former study looked at studies that considered the link between psychological traits and accident involvement. The authors performed a separate analysis for various predictor variables, and also considered the effect of moderators. Among their conclusions, Arthur et al. (1991) indicate that, "Better selective attention, higher regard for authority, an internal locus of control, and higher cognitive ability were associated with lower levels of accident involvement" (p. 97). Clarke and Robertson performed a meta-analysis relating accident involvement, in occupational and non-occupational settings, to the Big Five personality dimensions—which comprise extraversion, emotional stability (neuroticism), conscientiousness, agreeableness, and openness. By distinguishing between occupational and non-occupational accidents, the authors were able to study context as a moderator in predicting accidents. The authors found that, "Individuals low in agreeableness and low in conscientiousness are more liable to be accident-involved" (p. 369). When analyzed in different settings (i.e., occupational and non-occupational), the authors found that, "In occupational settings, low agreeableness and neuroticism were valid and generalizable predictors of accidents, while for traffic accidents (non-occupational), extraversion, low conscientiousness and low agreeableness were significant" (p. 369).

Arthur and Doverspike (2001) considered the correlation between crashes and driving knowledge, as well as crashes and personality traits. The authors included 48 persons in the study. In addition to answering 50 driving knowledge related questions, they also completed a personality measure. The authors found that conscientiousness was significantly correlated with both fewer not-at-fault and fewer total crashes; while driving knowledge was not significantly correlated with crashes. This may be an indication that conscientious behavior should be taught and stressed in driving school (Arthur and Doverspike 2001).

In another article by Arthur and Doverspike (1992), the authors investigated whether locus of control or selective attention was associated with being involved in a vehicular accident. Their objectives were to determine if the relationship between locus of control and vehicular accident involvement could be determined in a predictive manner using a longitudinal study compared to a postdictive design; to determine if locus of control or selective attention was a better indicator of vehicular accident involvement; and to determine if these two traits (locus of control and selective attention) were more effective indicators of accident involvement when used in tandem than when considered alone. They found that selective attention was a better predictor than locus of control of accident involvement. Locus of control did not prove to be an effective indicator of accident involvement either in tandem with selective attentiveness or in the postdictive or predictive studies performed (Arthur and Doverspike 1992).

Dahlen, Martin, Ragan, and Kuhlman (2005) performed a study wherein they considered traits including driving anger, sensation seeking, impulsiveness, and boredom proneness. The study was based on responses obtained from 224 college students. The Driving Anger Scale (DAS) was used, along with the Driving Anger Expression Inventory, the Arnett Inventory of Sensation Seeking, the Barratt Impulsiveness Scale, and the Boredom Proneness Scale. Likewise, questions related to "the frequency of problematic driving behavior and adverse outcomes" were gathered using a driving survey. Among the important findings was that, beyond its ability to predict risky driving, sensation seeking "also predicted aggressive driving, maladaptive driving anger expression, and certain crash-related conditions" (p. 346). The authors also note that their study "provided further support of the utility of the DAS in predicting unsafe driving" (p. 346).

An important statement made by Dahlen et al. (2005) is that "Internal consistencies for aggressive driving and risky driving range between 0.83 and 0.89, however, crash-related items do not generally form a reliable scale and are usually analyzed individually" (p. 343). A study performed by Deffenbacher et al. (2001) also included an analysis of questionnaire data at the item level. As part of the present study, an attempt was made to analyze some of the items as a scale; although particular attention was also given to the impact of individual items on the discrete choice modeling outcome.

Another topic covered in the literature is traffic violations and how various moods can impact driving. Chliaoutakis, Demakakos, Tzamalouka, Bakou, Koumaki, and

Darviri (2002) performed a related study in Greece. The results were based on surveys obtained from 356 young drivers using a self-report, 5-point Likert scale. Both principal components analysis and multiple regression analysis were used. The two factors of driving violations and irritability while driving stemmed from the questions pertaining to aggressive driving. The authors determined that, "Those young drivers who systematically misuse their car, face higher car crash risk than the average young driver" (p. 442).

The relationship between personality traits and mode choice selection was the focus of Johansson, Heldt, and Johansson (2006) They considered the effect that personality and attitude can have in mode choice selection. Both attitudinal and behavioral questions were included in the study. Results were obtained from 1,708 commuters in Sweden, where the modes of train, bus, and car were available. Latent variables were created and used in discrete choice modeling. The latent variables addressed modal comfort, modal convenience, environmental preferences, individual preference for flexibility, and individual preference for safety. The authors wanted to see if "manifested behavior in other areas of everyday life can help us better understand the driving forces behind mode choice" (p. 509). Based on their results and observations, the authors state that attitudinal indicators may be more desirable than behavioral variables because they lead to higher construct reliability and are easier to create. However, behavioral indicators are more external to mode choice. The authors found that those with environmental preferences are more likely to choose the mode train over bus. Likewise, flexibility and comfort also play a role in mode selection. The authors conclude that, “On several accounts our ‘latent variables enriched’ choice model outperforms a traditional choice model and provides insights into the importance of unobservable variables in mode choice” (p. 517). The same may be true of choices made in ML settings, which was one of the motivations behind the present study. Essentially, we want to better understand some of the “unobservable variables”—namely psychological characteristics—that may be contributing to people’s travel behavior in ML settings (i.e., lane choice and/or carpooling decisions).

As evidenced by this review of the literature on psychology in transportation, a wide array of psychological characteristics (i.e., locus of control, conscientiousness, extraversion, etc.) have been studied in relation to varied transportation events (i.e., traffic crashes, traffic violations, mode choice, etc.). However, the literature on the psychology behind ML use decisions is limited, and is largely rooted in preliminary work performed by Burris et al. (2012a) and Green and Burris (2014). Through the development of additional, focused psychological items that are largely framed in a transportation context, the present research helps to fill a void in the literature on psychology in transportation, and contribute to a better understanding of travel behavior on MLs.

4.4 Stated Preference Questions

Both SP questions and revealed preference (RP) questions have inherent strengths and weaknesses, as will be discussed in greater detail within this section. Two common types of SP question designs—namely efficient designs and adaptive designs—will also be described, as these design types were incorporated into the survey performed as part of this research effort.

4.4.1 Stated Preference Questions vs. Revealed Preference Questions

SP questions are common in transportation research. Their strength rests on the fact that they allow for data to be collected using scenarios that may not reflect current conditions. Hence, in contrast to RP questions where respondents are asked about decisions that have already been made, SP questions allow for more hypothetical scenarios and can enable researchers to elicit information about what respondents would likely do in a hypothetical situation. With SP questions, the researcher must determine the attribute levels before administering a survey (Hensher et al. 2005).

Hensher (1994) outlines several of the key factors to consider with SP surveys. First, he explains that there are both stated choice models and SP models. Within SP surveys, respondents can be asked to either rate or rank their preferences for various alternatives. In stated choice surveys, respondents simply make a choice amongst the alternatives that are presented. Hensher cautions that the attribute levels selected in either SP or stated choice surveys should be reasonable, despite the fact that they can be hypothetical. Different types of experimental designs are mentioned by Hensher as well. In a full factorial design, all attribute levels of all alternatives are shown. However, to increase the practicality of surveys, often a fractional factorial design is used to simplify things, despite the fact that this approach decreases the efficiency of the design. Another thing to consider in the statistical design of SP surveys is the issue of orthogonality. Speaking of orthogonality, Hensher states, "This property of zero-correlation between attributes enables the analyst to undertake tests of the statistical contribution of main effects and interactions, and is promoted as a major appeal of SP data compared to RP data" (p. 117). However, orthogonality is not a requirement of SP design (Hensher 1994). The following subsections will further discuss the two types of experimental designs that were addressed as part of this research; namely efficient designs and adaptive designs.

4.4.2 Efficient Designs

What makes an experimental design an "efficient design"? According to Hess, Smith, Falzarono, and Stubits (2008, p. 147):

> *That is, a statistically efficient design is constructed with the aim of maximizing the asymptotic t-ratios obtained from data collected using the design. The construction of an efficient design therefore requires construction of the likely asymptotic (co)variance matrix before data are collected. This requires that the attribute levels and parameter estimates be known in advance.*

Some research has examined the effectiveness of efficient designs with SP surveys. For instance, Hess et al. (2008) collected SP data related to toll initiatives in the Atlanta, Georgia area. Responses were obtained from 4,173 travelers and the results allowed for comparisons to be made between orthogonal designs with random and non-random blocking, and efficient designs. Their results indicated that different experimental designs can lead to differences in value of time (VOT) and elasticities, which in turn can lead to different policies being implemented based on SP survey results. They found that random blocking contributed to overestimation of the VTTS, although non-random blocking results led to comparable results when compared to the efficient design. However, the authors recommend further research be done that compares different experimental designs in SP surveys (Hess et al. 2008).

The methodology used to determine the attribute levels used in the present study largely stem from the methodology employed by Burris et al. (2012a). For the D_b-efficient (DBE) design, five blocks each consisting of three rows were used, with each respondent being assigned the three questions associated with a given block. Halton draws (Hensher et al. 2005) were used in determining the priors (parameter estimates) information needed for the DBE design (M. Burris, Arthur et al., 2012) . See Section 5.6 for a further description of the attribute levels used in this survey.

4.4.3 Adaptive Designs

Characteristics associated with adaptive SP designs include simplified questions, fewer alternatives associated with each question, attribute levels that are affected by a respondent's previous question response(s), more games being included in the survey, and parameters being estimated at an individual respondent level (Richardson 2002). Critics of adaptive SP designs argue that because they are not orthogonally designed, they can lead to biased means and standard deviations in estimating parameters. Richardson performed a simulation of an adaptive SP design of 1,000 respondents. He found that a seven-point Likert scale produced the most desirable results. Richardson concluded that it is possible to estimate parameters with an unbiased mean and standard deviation using an adaptive SP design. Specifically, he was able to estimate the VOT parameter using this approach. Richardson notes optimal VOT results were obtained when the initial VOT estimate was higher than what the average VOT was found to be (roughly twice as large as the average) (Richardson 2002).

Patil et al. (2011) compared three experimental design types—namely D-efficient, random attribute, and adaptive random (AR)—using responses from 2,898 travelers who were familiar with the Katy Freeway. At the time of the survey (i.e., 2008), the Katy Freeway was operating under an HOV setting, where 2+ person vehicles could travel for free in the ML during peak periods, and pay a toll in the off-peak periods. However, some of the SP alternatives tried to assess how single occupancy vehicles (SOVs) would respond if there were an option to pay a toll for use of the ML. Based on a comparison of the results obtained using all three experimental design types, the authors concluded that the different approaches resulted in different VTTS estimates. The AR method was determined to be the best overall method. It had the highest adjusted rho squared value, less non-trading respondents, fewer respondents consistently choosing the cheapest alternative, and a similar efficiency in estimating parameters as the D-efficient design. However, the VTTS estimates obtained using the D-efficient design seemed the most reasonable when compared to previously obtained estimates (Patil et al. 2011). These results leave room for further research to support or counter these findings. Further comparison of efficient and adaptive designs were performed as part of the present study. This comparison took a form somewhat similar to part of what was employed by Patil et al. (2011), comparing the adjusted rho squared value and VTTS. However, for the purposes of analyzing the psychological items, data obtained using both design types were combined to maximize the sample size.

For the adaptive design performed in the present study, the travel times and tolls originally shown to the respondent were random, within defined boundaries, but were adjusted for subsequent SP questions based on the responses received from a respondent's previous SP question response(s). If a tolling option was selected, subsequent tolls were 15 to 75 percent higher for the next question; whereas, if a tolling option was not selected, subsequent tolls were 15 to 50 percent lower for the next question (Burris et al. 2012a). No toll shown within the survey was permitted to exceed $10. The software Ngene was used in the creation of the DBE design.

4.5 Discrete Choice Modeling: Logit Models

As the name implies, discrete choice modeling is associated with analyzing data that elicit responses wherein respondents are required to select between a given set of alternatives. Logit models are a common branch of models commonly used in discrete choice modeling. The computer program NLOGIT (Greene (c) 1986-2012) allows for discrete choice data to be input and manipulated for use in generating models that help in determining the significance and usefulness of different items. Subsequent analysis can help transportation engineers and planners to better understand what attributes are related to choices made in a transportation setting. Ultimately, this information can lead to better understanding of transportation decisions and may aid in enacting policies that address concerns of equity, public perception, and mode-use, among others. Within this section, a brief overview of discrete choice modeling is provided. Next, a detailed description of multinomial logit (MNL) models—particularly mixed logit models—is provided, along with an explanation of why this modeling approach will be used in the present study.

4.5.1 Discrete Choice Modeling

One of the major assumptions made in analyzing traveler's choices is that choices are made based on a desire to maximize utility, or minimize disutility. However, the actual utility of a given alternative is composed of observed utility and unobserved utility. Thus, utility is denoted by Equation (2) (Hensher et al. 2005, p. 75) as follows:

$$U_i = V_i + \varepsilon_i \qquad (2)$$

where

U_i=overall utility of alternative *i*

V_i=observed utility of alternative *i*

ε_i=unobserved utility of alternative *i*

After considering the utility associated with each alternative in consideration, the probability of a particular alternative being selected can best be described by Equation (3).

$$Prob_i = Prob[(\varepsilon_j - \varepsilon_i) \leq (V_i - V_j) \forall j \varepsilon \{1, \ldots, J; i \neq j\} \qquad (3)$$

where

$C = \{1,2, \ldots, J; i \neq j\}$

Equation (3) is described by Hensher et al. (2005, p. 83), using the following statement:

> *In words*, the probability of an individual choosing alternative *i* [Prob *i*] is equal to the probability that the difference in the unobserved sources of utility of alternative *j* compared to *i* is less than (or equal to) the difference in the observed sources of utility associated with alternative *i* compared to alternative *j* after evaluating each and every alternative in the choice set [C] of *j*=1,…*i*,…*J* alternatives.

Now that the basis of discrete choice modeling has been described, a description of MNL models—the group of models that will be used in the current research project—is provided in the next subsection.

4.5.2 Multinomial Logit Models

MNL models, as the name implies, are used in modeling survey data that have multiple potential alternatives that can be selected. According to Hensher et al. (2005), MNL models are "the 'workhorse' of discrete choice analysis" (p. 85). The equation denoting MNL models is shown in Equation (4):

$$Prob_i = \frac{\exp V_i}{\sum_{j=1}^{j} \exp V_j}; \text{ j=1,…,}i\text{,…,}J\ i \neq j \qquad (4)$$

Hensher et al. (2005, p. 86) succinctly describe Equation (4) by stating the following:

> *In words*, [Equation (4)] states that the probability of an individual choosing alternative *i* out of the set of *J* alternatives is equal to the ratio of the (exponential of the) observed utility index for alternative *i* to the sum of the exponentials of the observed utility indices for all *J* alternatives, including the *i*th alternative.

In comparing MNL models, two of the key outputs that are often used is the adjusted rho squared value and the percent correctly predicted value. High correct predictability is obviously desirable. Similarly, it is desirable to have a high adjusted rho squared value. It is adjusted in the sense that it takes into consideration the number of parameters included in the model; thereby putting a penalty on models incorporating a high number of parameters and representing the need for a balance between model simplicity and added information obtained from using additional parameters. The specific equation used in calculating the adjusted rho squared value for the present study, along with further discussion on adjusted rho squared values, is provided in Subsection 6.4.1.

4.5.3 Mixed Multinomial Logit Models

In the present study, mixed logit models, which are a specific type of MNL models, were used. The strength of mixed logit models lies in their ability to handle heterogeneity within data, by making at least one of the parameters random. As stated by Koppelman and Bhat, "The MMNL [mixed multinomial logit] model structure also serves as a comprehensive framework for relaxing both the IID [independent and identically distributed] error structure as well as the response homogeneity assumption"

(Koppelman and Bhat 2006, p. 220). The general equation for mixed logit models is shown in Equation (5) (Train 2009).

$$U_{nj} = \beta_n' x_{nj} + \varepsilon_{nj} \quad (5)$$

where

β_n=vector of coefficients of these variables for person n representing that person's tastes

x_{nj}=observed variables that relate to the alternative and decision maker

ε_{nj}=random term that is IID extreme value

In mixed logit models, the β_n from Equation (5) (referred to as β_q by Hensher et al., 2005), (which is not observed by the analyst), allows for "additional stochastic elements that may be heteroskedastic and correlated across alternatives" (Hensher et al. 2005, p. 606-607). β_q can also be written in a form equivalent to β_{qk} as shown below in Equation (6) (Hensher et al. 2005, p. 607; Devarasetty 2012, p. 31):

$$\beta_{qk} = \beta_k + \boldsymbol{\delta}'_k \boldsymbol{z}_q + \boldsymbol{\eta}_{qk} \quad (6)$$

where

$\delta'_k \boldsymbol{z}_q$=observed heterogeneity around the mean of the kth random parameter (δ_k is to be estimated and $\boldsymbol{z}_q$ is an observed data vector which may contain individual specific characteristics such as socio-demographic characteristics)

$\boldsymbol{\eta}_{qk}$=random term, with distribution over individuals depending in general on underlying parameters

One distinguishing feature of mixed logit models is the ability for η_{qk} to have different distributions (i.e., normal, triangular, lognormal, etc.). Within a mixed logit model, it is possible to "specify the distribution that the analyst wishes to impose upon each of random parameters" (Hensher et al. 2005, p. 624). Within the models created as part of this research effort, travel time was associated a triangular distribution and the ASCs were assigned a normal distribution. Through simulated draws, the random parameters are defined from the sample data. While random sampling is one option, there are intelligent draw methods that can save the analyst significant time (Hensher et al., 2005) . Halton draws are one of the most popular intelligent draw techniques and were employed in this analysis (Hensher et al. 2005). During many of the preliminary, exploratory models created, 20 Halton draws and a maximum of 20 iterations were employed. However, all finalized models discussed in the present research were based on 500 Halton draws and a maximum of 500 iterations (though fewer iterations were needed to obtain the results).

4.6 Summary

A thorough review of the literature related to MLs, scale construction, psychology research in a transportation setting, SP questions, and discrete choice-logit models has helped to solidify both the need for, and ability to perform, the present research effort. MLs are becoming increasingly prevalent in the USA, given their aim to help with congestion management along busy corridors. Thus, it is important to understand the factors contributing to their use. While socio-demographic variables are often used in this pursuit, psychological characteristics are another avenue that may help in understanding ML travel behavior. Barring the preliminary research performed by Burris et al. (2012a) and Green and Burris (2014), research on the psychology behind ML use has been largely unexplored. Although a significant amount of work has been performed on how the psychological characteristics of drivers may be used in predicting transportation related outcomes such as crashes, road rage, and traffic violations, this field of work has not yet been fully extended to the area of travel behavior on MLs. This research contributes to the existing body of literature through the development of psychological items; some of which help predict ML travel behavior, as modeled through the use of SP data. The computer program, NLOGIT (Greene (c) 1986-2012), which is an extension of LIMDEP (Econometric Software (c) 1986-2012), was used in developing MNL models that contribute to better understanding and prediction of ML travel behavior. Reason et al. stated that, “Driving behaviour is extremely complex. No one method of investigation can capture all of its intricacies” (p. 1327). Consequently, the present study contributes to the body of existing knowledge on travel behavior—addressing current gaps in the literature and helping to advance our understanding of travel behavior in a ML context (i.e., lane choice and/or carpooling decisions).

5. METHODOLOGY

The objective of this research was to better understand travel behavior on MLs. As such, psychological items, largely framed in a transportation context, were developed. Responses to these psychological items, groups of these psychological items that formed scales intended to measure the constructs of interest, and trip and demographic information were used to develop discrete choice models used in predicting ML travel behavior (i.e., lane choice and/or carpooling behavior). This chapter explains the details of this effort, as well as a description of the methodology that was employed.

Note that in referring to the survey performed as part of the present research, the term “express lane” (EL) will be used instead of “managed lane” (ML), as this was the terminology used in the survey. A small exception was applied to the Seattle survey, where the term “express toll lane” was used, where appropriate, upon request of transportation professionals from the area. The terms “express lanes” and “managed lanes” are sometimes used interchangeably, though some may think of express lanes as a specific type of managed lane. In other words, the exact relationship between the two terms is somewhat vague and different ML operators call their lanes different names.

5.1 Study Setting

Originally, the intention was to make the survey available electronically to persons who live in six cities with EL corridors:

- SR 167 in Seattle, Washington
- I-15 in Salt Lake City, Utah
- I-10 and I-110 in Los Angeles, California

- I-495 on the Capital Beltway in the Washington, D.C. Area
- I-394 and I-35W in Minneapolis, Minnesota
- I-85 in Atlanta, Georgia

However, in contacting transportation professionals in each of these areas, Atlanta indicated that they were preparing to perform a survey of Atlanta ML users themselves, and could not assist with advertising our survey at the time. Thus, Atlanta was removed from the list of survey locations. The other five cities were retained for survey respondent recruitment. The following subsections provide a brief background on each of these EL corridors and some of their characteristics.

5.1.1 SR 167 in Seattle, Washington

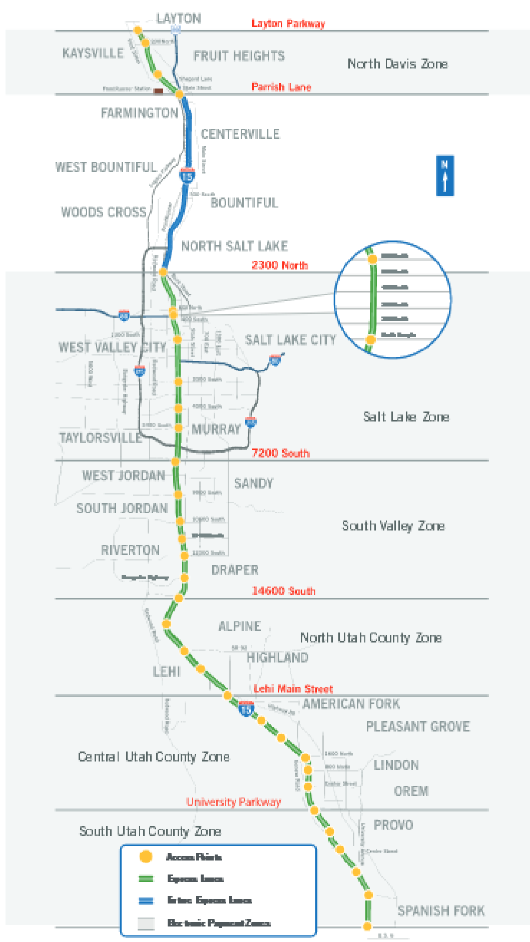
The SR 167 HOT lanes in the Seattle area is a 10 mile HOT lane between Renton and Auburn. It allows carpools of 2+ persons and motorcyclists to use the lane for free, while solo drivers can pay a toll to use the lane. The HOT lane rules are only in effect from 5 am to 7 pm, seven days a week, after which all travelers can use the HOT lane for free. The toll rate changes depending on the level of congestion and can range anywhere from $0.50 to $9. While carpoolers and motorcyclists do not need a transponder to use the HOT lane, SOVs and carpoolers who sometimes travel alone, need to purchase a *Good to Go!* pass to travel in the HOT lane. The HOT lane is separated from the GPLs by a double white-line (Washington State Department of Transportation 2014a). Within the survey, the wording “SR 167 HOT lanes (also known as Express Toll Lanes)” was used in referring to the EL corridor, where appropriate. A map showing the location of SR 167 is shown in Figure 2.

Source: Washington State Department of Transportation 2014b

Figure 2. Map showing SR-167 ELs near Seattle.

5.1.2 I-15 in Salt Lake City, Utah

Carpool lanes were first operational in Utah along I-15 in 2001. These carpool lanes have since evolved to HOT lanes and cover 62 miles of roadway, and includes the longest continuous carpool lanes in the country (Utah Department of Transportation 2014). The roadway runs north-south and spans from "U.S. 6 in Spanish Fork to 2300 North in Salt Lake and from Parrish Lane in Centerville to Layton Parkway" (Utah Department of Transportation 2014). The HOT lanes are divided into six zones, and between $0.25 and $1 is charged per zone, depending on the amount of congestion being experienced. It is the hope that the speed along the ML will be kept at 55 miles per hour (mph) or higher. Carpoolers (2+ vehicles), motorcyclists, and electric vehicles can use the lane for free at all times. SOV drivers can use the EL if they have purchased an Express Pass. The pass itself is only $8.75, but at least $25 must be deposited when the transponder is purchased (Utah Department of Transportation 2014). A rough sketch of where the Utah ELs are is shown in Figure 3.



Source: Utah Department of Transportation 2014

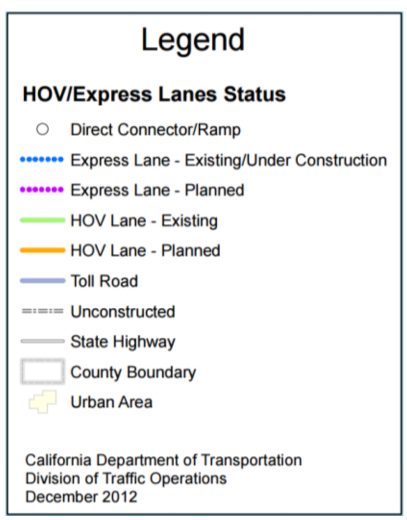
Figure 3. MLs along I-15 in Utah

5.1.3 1-10 and I-110 Los Angeles, California

The carpool lanes along I-10 and I-110 in Los Angeles County, California were recently (November 2012 and February 2013, respectively) altered to be HOT lanes, where congestion pricing is implemented (Expresslanes 2014a). Specifically, the HOT lanes span from “I-110 Harbor Transitway (between Adams Blvd. and Harbor Gateway Transit Center) and the I-10 El Monte busway (between Alameda St. and I-605)”. Vehicles with 3+ persons can use the lanes for free, vehicles with 2+ persons can use the lanes for free during the off-peak period and pay a toll to use the HOT lanes during the peak-period, and solo drivers can pay a toll to use the HOT lanes. Depending on the level of congestion, the tolls can range from $0.25 per mile to $1.40 per mile. All users of the HOT lanes, including carpoolers, must purchase a FasTrak transponder. The HOT lanes were opened as part of a Congestion Reduction Demonstration Program. It is the hope that a minimum of 45 mph speed can be maintained on the HOT lanes at all times. As part of an effort to address equity issues, low income households meeting the specified requirements are given a $25 credit when they set-up their transponder account. Along with the conversion to HOT lanes, some changes were made to the EL configuration. A lane was added on El Monte Busway between I-710 and I-605, and parts of Adams Boulevard were widened and restriped to help address congestion issues (Expresslanes 2014b). A map showing the MLs that are built and planned in the LA area as of February 2012 (including I-10 and I-110) is shown in Figure 4, while the corresponding legend is shown in Figure 5.

Source: California Department of Transportation 2012

Figure 4. Map showing MLs in Los Angeles, California area (including I-10 and I-110).

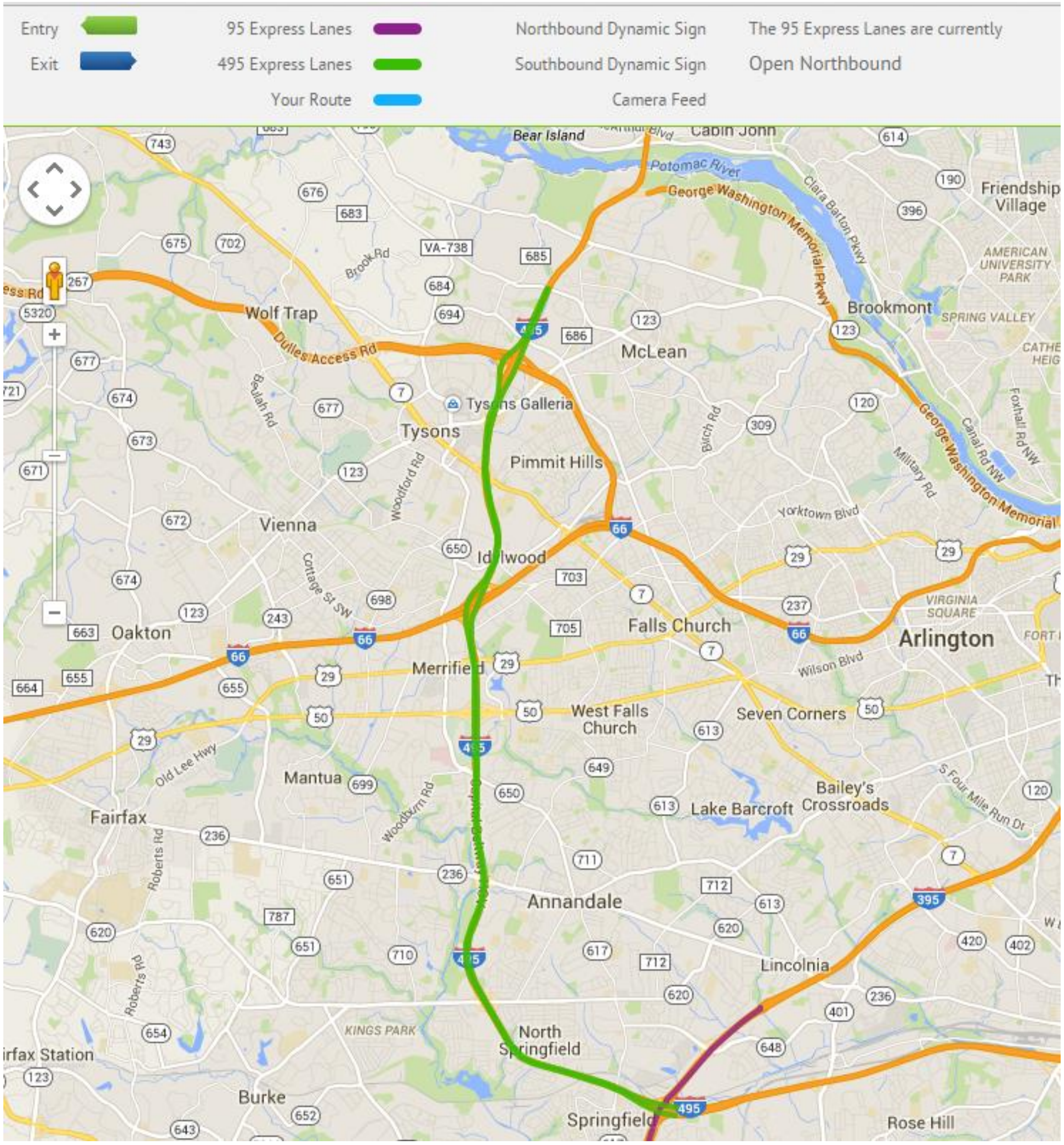


Source: California Department of Transportation 2012

Figure 5. Legend corresponding to Figure 4 map.

5.1.4 I-495 on the Capital Beltway in the Washington, D.C. Area

The MLs along I-495 in northern Virginia on the Capital Beltway in DC consist of two HOT lanes in each direction, and are referred to as ELs. They consist of approximately 14 miles of roadway and allow vehicles with 3+ persons, emergency vehicles, motorcycles, and buses to use the lanes for free. The ELs run “from the Springfield Interchange to just north of the Dulles Toll Road” (Transurban (USA) Operations Inc.-a 2015). Unlike some other states, Virginia law does not permit hybrid vehicles to be allowed to travel on HOT lanes for free, merely because of this vehicle-type status. No trailers or vehicles with more than two axles are allowed on the ELs. The toll rates vary dynamically, and no cap on tolls is provided. The ELs are in effect 24-hours a day, seven days a week. It is required to have an E-ZPass Flex to use the ELs. This type of transponder allows motorists to declare whether they are traveling with an HOV or paying to use the HOT lane. The lanes are managed in an attempt to achieve an average speed of 65 mph in the ELs (Transurban (USA) Operations Inc.-a 2015). A map showing where the I-495 ELs are located, along with where the planned ELs on I-95 will be built, is shown in Figure 6.

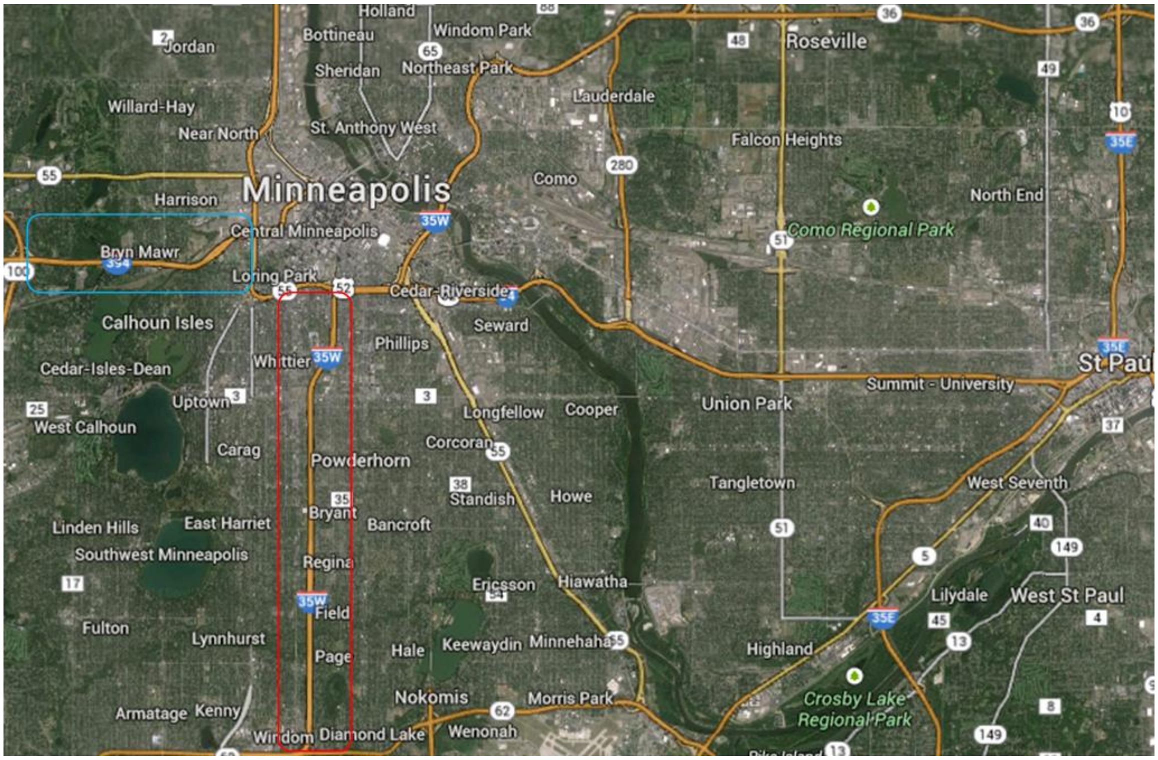


Source: Transurban (USA) Operations Inc.-b, 2015

Figure 6. Map showing I-495 on the Capital Beltway in Washington, D.C.

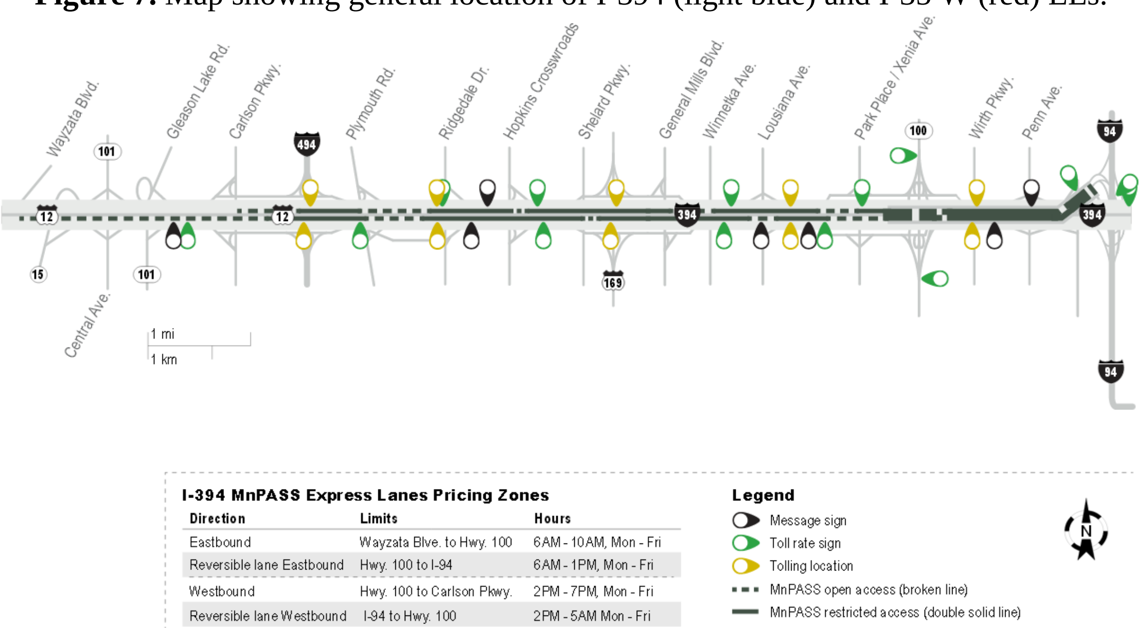
5.1.5 I-394 and I-35W in Minneapolis, Minnesota

HOT lanes, also referred to as ELs, exist on both I-394 and I-35W in Minneapolis, Minnesota. I-394 opened in May 2005 and was funded through a PPP between the State of Minnesota and Wilbur Smith Associates (who funded 20 percent of the $10 million project). I-35W opened in September 2009 and helps to connect travelers traveling to and from south of downtown Minn (Minnesota Department of Transportation 2013a). The hours of operation for the ELs vary by direction and location. Transit vehicles and carpools of 2+ persons can use the ELs for free, and SOV can choose to pay a toll. Carpoolers are not required to have a MnPass to use the ELs, but SOV wanting to use the ELs must lease a MnPass, with a minimum charge of $1.50 per month. The toll per segment of the EL can vary from anywhere from $0.25 to $8, with an average of a $1 to $4 toll during the peak period. It is not permissible to cross the double white lines associated with the ELs. On portions of I-35W, there is also the option of using the left shoulder as an additional HOT lane during some congested periods. The ELs on I-394 are reversible and are altered depending on the day and time (Minnesota Department of Transportation 2013b). A map showing the general locations of I-394 and I-35W in Minn is shown in Figure 7, while a more detailed schematic of I-394 and I-35W is shown Figure 8 and Figure 9, respectively.



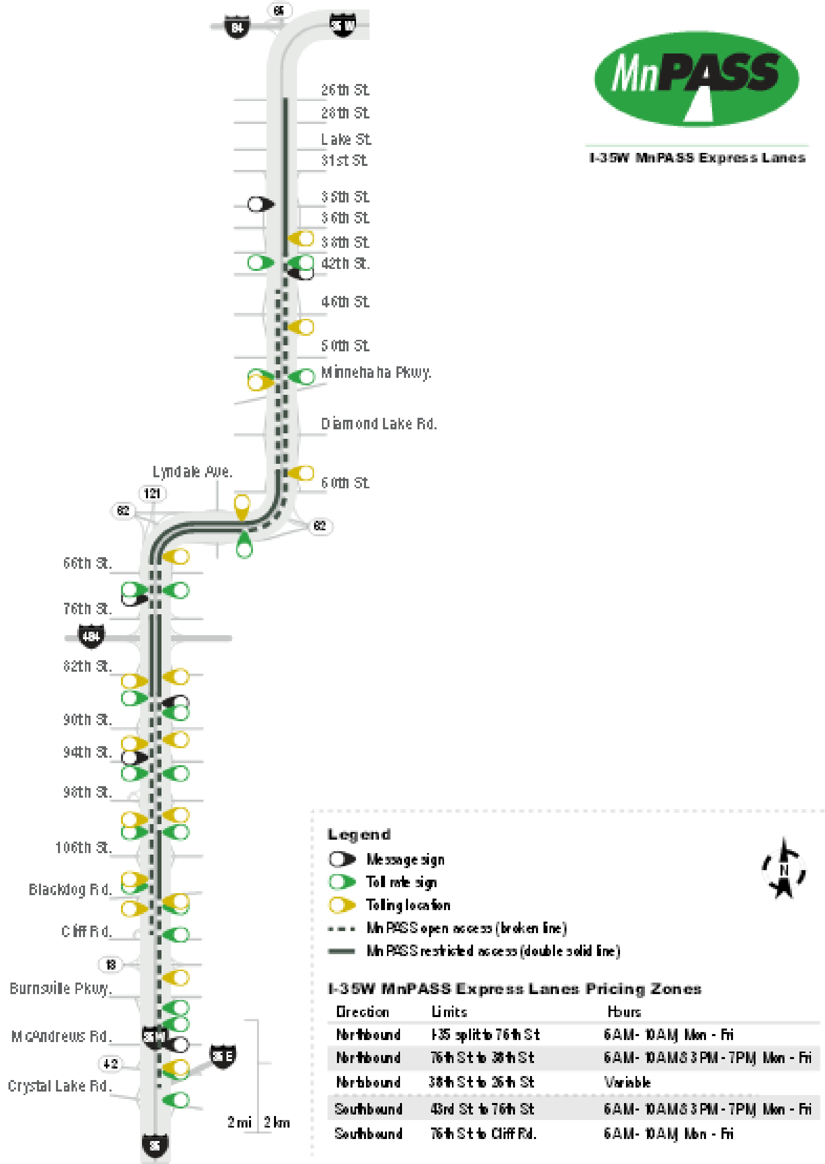
Source: Google Maps 2014

Figure 7. Map showing general location of I-394 (light blue) and I-35 W (red) ELs.



Source: Minnesota Department of Transportation 2013c

Figure 8. Map showing I-394 ELs in Minneapolis, Minnesota.



Direction	Limits	Hours
Northbound	I-35 split to 76th St	6AM - 10AM, Mon - Fri
Northbound	76th St to 38th St	6AM - 10AM & 3PM - 7PM, Mon - Fri
Northbound	38th St to 26th St	Variable
Southbound	43rd St to 76th St	6AM - 10AM & 3PM - 7PM, Mon - Fri
Southbound	76th St to Cliff Rd.	6AM - 10AM, Mon - Fri

Source: Minnesota Department of Transportation 2013c

Figure 9. Map showing I-35W ELs in Minneapolis, Minnesota.

5.2 Psychological Item Development

The process of developing the psychological items for inclusion in the survey consisted of several steps. First, the psychological items included in the research by Burris et al. (2012a) were analyzed as part of research performed by Green and Burris (2014). As the number of Halton draws performed varied, there was some variation in psychological items that were significant when considered in a model containing ASCs, travel time, toll, and all of the psychological items from a given scale or subscale. Any psychological item associated with significance at the 90% confidence level or higher, under any of the Halton draw variations attempted, were taken as a starting point in developing new psychological items created in hopes of better understanding travel behavior on ELs.

Having identified those psychological items that showed promise for further investigation, the next consideration was to develop items framed in a transportation context. By contextualizing the items, it was hypothesized that it may improve the ability of the items to provide meaningful insight into transportation. Research performed by Schmit, Stierwalt, Ryan, and Powell (1995) considered the effect that framing items in a context-specific setting had in using personality tests to aid in selecting which personnel to hire. Based on a study they performed, they concluded that greater validity was associated with context-specific items.

A large portion of the developed items specifically relate to EL use, although some items merely fit into the broader category of transportation. A handful of items related to risk that are not framed in a transportation context were retained for consideration because they showed promise in preliminary research (Green and Burris 2014). After initial brainstorming took place for new item development, the field of potential items to include was reduced to minimize repetitious items.

Then, preliminary construct definitions were created with an effort to group the initial pool of items into these defined categories. Additional items related to how people make driving decisions were created after receiving the comment from the dissertation committee that this would be an interesting area to consider (i.e., related to the "Analytical Tendency in Decision Making Process" construct). While some of the construct definitions are related to constructs used in previous research, they are not identical.

5.3 Item Sort Form

Next, five individuals were asked to complete the Item Sort Form based on these items and constructs—providing feedback on what could be changed or clarified to improve the form. Upon implementing the suggested improvements, a convenienced sample of 21 individuals was asked to complete the Item Sort Form. The Item Sort Form consisted of 43 psychological items (see Appendix A for the Item Sort Form). The responses obtained from the 21 respondents were aggregated. All 21 respondents sorted 42 of the psychological items, while one respondent skipped sorting one of the psychological items.

The next step was to calculate the substantive agreement and substantive-validity coefficient for each psychological item (refer to Section 4.2.2 for previously provided details). A critical substantive-validity coefficient value of 0.43 and 0.50 were calculated for respondent sizes of 21 and 20, respectively. Of the 43 psychological items, 16 of them had a substantive-validity coefficient greater than the appropriate critical (cut-off) value. Thus, these questions were included in the next round of question testing. Although substantive agreement (which for this research was taken to be the percent of respondents assigning an item to the most popularly assigned construct) was calculated, it was not used in making decisions on which psychological items to retain for the next round of data testing.

There were several questions that did not have a substantive-validity coefficient greater than the critical value, but were of interest to the researchers. Thus, an additional 16 questions (32 questions total) were kept for the next round of data testing. In other words, 11 of the 43 questions included in the Item Sort Form were dropped prior to the Paper Survey, which is described in the next section.

5.4 Paper Survey

Based on the question refinement that took place as part of the Item Sort Form analysis, the next step was to have another convenienced sample complete a preliminary form of the survey. A total of 118 surveys were received between June 9, 2014 and June 16, 2014. Though a majority of the completed preliminary forms were completed electronically (102 surveys received electronically as opposed to 16 received in paper form), the preliminary form survey will be referred to as the "Paper Survey" (see Appendix B) throughout the remainder of the present research. The Paper Survey consisted of 32 psychological items, along with three SP questions related to mode choice in ML settings. Each psychological item was responded to on a 9-point Likert scale.

A handful of the 118 respondents had also completed the Item Sort Form discussed in the previous section. While the surveys submitted by these individuals were marked so that they could be easily identified should a question arise, there is no reason to believe that their participation in a previous phase of the question refinement process would have affected the results, because several weeks passed between when the Item Sort Forms and Paper Surveys were administered.

Not every respondent answered every question. Of the 118 respondents, 82 responded to all 32 psychological items. Eight of the respondents did not respond to the last six items, which may have been because they did not see the questions that were on the last page of the survey. These questions would be especially easy to miss for respondents completing the Paper Survey electronically.

Additionally, respondents were instructed to skip questions related to MLs if they felt they could not answer them. Providing this instruction was important, because it was not a requirement that the Paper Survey respondents be from areas with MLs. However, it was of interest to analyze the relationship between the psychological item responses and the SP responses using the Paper Survey, in order to help refine and finalize the psychological items to include in the online survey. Thus, having respondents answer ML related questions that they did not feel comfortable answering may have skewed the results. Regardless of the reason for skipped items, the responses that were received were used in the analysis performed to finalize the psychological items to use in the online survey, with a varying number of responses obtained for each psychological item.

5.5 Paper Survey Data Analysis

The data obtained through the Paper Survey were analyzed using Cronbach's alpha, EFA, and Kruskal-Wallis test procedures. The analysis process associated with the Paper Survey is described in the following subsections. Further details associated with the Paper Survey data analysis are provided in a report created by Florence (2014).

5.5.1 Cronbach's Alpha

Mathematically, Cronbach's alpha values can range from negative infinity to 1, with values closer to 1 indicating a higher reliability score. However, negative Cronbach's alpha values can be related to issues with the score integrity (Thompson 2003). A Cronbach's alpha value of 0.7 or higher is often taken in the literature to be adequate, though some may argue that further consideration, such as number of items in a scale, should be taken before coming to this conclusion (Cortina 1993). Cronbach's alpha is calculated using Equation (7) (Thompson 2003).

$$\alpha = \frac{K}{K-1}\left[1 - \left(\sum \sigma_k^2 / \sigma_{TOTAL}^2\right)\right] \tag{7}$$

where

α=Cronbach's alpha

K=number of items

$\sum \sigma_k^2$=sum of the k item score variances

σ_{TOTAL}^2=variance of the scores on the total test

Initially, the Cronbach's alpha value was calculated for the scales, or groups of items, associated with each construct. An item was considered to be part of a given construct based on whichever construct it was most often sorted into in the Item Sort Form analysis. Once the initial Cronbach's alpha value for the scale associated with each construct was calculated, items were then iteratively dropped, one-at-a-time. The decision of which item to drop next was determined based on whichever item removal would lead to the highest new overall Cronbach's alpha value. This process of removing items from the scales associated with a given construct continued until the removal of an additional item no longer improved the overall Cronbach's alpha value of the scale. In other words, in the end, only those items that contributed toward a higher Cronbach's alpha value for their respective scales were retained. This process aided in identifying those psychological items that should potentially be deleted due to reliability issues, in an effort to decrease the number of psychological items included in the final survey.

Only one scale associated with a construct ("Reliance on Others") resulted in a Cronbach's alpha value greater than 0.7 (with an alpha value of 0.772). However, the items associated with the highest Cronbach's alpha value for a given scale were also deemed acceptable for retention in the online survey if the items correlated well with the scale (i.e., had a correlation coefficient value of 0.3 or higher), despite not having a Cronbach's alpha value greater than 0.7. This multi-faceted criterion resulted in 17 psychological items associated with four constructs being recommended for inclusion in the online survey.

5.5.2 Exploratory Factor Analyses

At the same time that the Cronbach's alpha analysis related to reliability was performed, a separate EFA analysis was undertaken to further refine and develop the scales. Based on the Item Sort Form results, there was a priori idea of which items should belong to the scale associated with a given construct. Therefore, it would have been ideal for a CFA to be performed to see if the psychological items hypothesized to be associated with a given construct coincided appropriately. However, it was not possible to perform a CFA within SPSS (IBM Corp. (c) 1989, 2013). Therefore, rather than perform a CFA, an EFA was performed, wherein SPSS was forced to extract only one factor per hypothesized scale—thereby, in many ways mimicking a CFA. For example, based on the Item Sort Form results, the "Reliance on Others" construct was hypothesized to be associated with a scale that included four psychological items. Therefore, within the EFA, SPSS was forced to extract just one factor for these four psychological items. The component matrix value output was then assessed for each psychological item. Those psychological items associated with a positive but small component matrix value (0 to 0.1), or a negative component matrix value, were flagged as potential psychological items to remove from their respective scale due to potential validity issues.

Based on the combined results of the Cronbach's alpha reliability analysis, and the EFA analysis, only 17 of the psychological items (belonging to one of four constructs) were recommended to be evaluated as part of a scale in discrete choice modeling. The scale associated with the "Desire for Predictability, Reliability, and

Consistency" construct did not perform well in the Cronbach's alpha analysis, and so was not retained for further analysis at the scale level. Also, the sub-scales associated with the two "Tendency to Take Risks" constructs (Transportation Related and Purely Financial) did not perform well alone in the Cronbach's alpha analysis. However, when combined into one scale associated with an overarching "Tendency to Take Risks" construct, the Cronbach's alpha results improved. Thus, these two sub-scales were combined in subsequent scale analyses.

5.5.3 Kruskal-Wallis Test

The next type of analysis that was performed using the data obtained from the Paper Survey was a Kruskal-Wallis test. Using the results of a post hoc, Kruskal-Wallis one-way ANOVA (k samples) test with pairwise comparisons (described in greater detail in Section 6.3.2) allowed for the comparison of the mean ranks associated with psychological item responses. This approach ultimately allowed for comparison of the distributions of psychological item responses between different mode groups. Those mode pairs that were found to have statistically significant different means ranks at a 0.05 significance level were flagged. Separate analyses were completed for the responses associated with each SP question (i.e., SP1, SP2, and SP3), as well as for the responses associated with respondents who selected the same mode for all three SP questions (SPA). Nineteen psychological items were found to have mean ranks that were statistically significantly different between at least two modes (at a 0.05 significance level), based on Likert scale responses obtained. Eight of these nineteen items were found to have significant differences in mean rank between at least two modes, based on Likert scale responses obtained, for two or more SP cases (i.e., SP1 and SPA, SP2 and SPA, SP2 and SP3, etc.).

The information contained in the following bullet points provide further detail about the 19 psychological items found to have at least one significant mean rank difference between modes:

- 14 of these psychological items were among the 17 psychological items that were already recommended for analysis as part of a scale based on the Cronbach's alpha and EFA results.
- Five of these psychological items did not belong to one of the four scales of interest. It was determined that these psychological items should be included in the online survey, though for analysis only at the item level, and not as part of a scale.

Three additional psychological items (beyond the 17 items recommended for analysis as part of a scale, as determined using the Cronbach's alpha and EFA results, and the five items with significant differences in mean ranks but not part of a retained scale) were also selected for inclusion in the online survey because they were of interest.

A summary of the 25 psychological items retained for inclusion in the online survey is provided in Table 1. Note that slight changes in wording were implemented to some of the questions prior to finalizing them for inclusion in the online survey.

Table 1. Reason for Retaining the 25 Psychological Items Included in Online Survey

17 Questions: Retained in online survey for further analyses as part of scale (based on Cronbach's alpha and EFA analyses).
PSY1: It does not matter if I choose the general purpose lane or managed lane since it is just luck if the managed lane saves me time.
PSY5: I have often found that what is going to happen will happen.
PSY 7: Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.
PSY8: Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.
PSY9[R]: I cannot understand why someone would pay to use the managed lanes when the general purpose lanes are available for "free", especially when it may or may not save time.
PSY12: The coordination involved with carpooling is more hassle than it is worth.
PSY13[+]: Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.
PSY14: I often look up information about traffic conditions prior to driving anywhere.
PSY15[+]: The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.
PSY16: I tend to make choice about which road to use based on the traffic I encounter.
PSY18: I listen to the radio while driving so I can get updates on traffic.
PSY19: I do not like relying on others for rides.
PSY21: Choosing to use the managed lane, knowing there is a 50 percent chance it will not save me time.
PSY22[+]: Investing 10% of your annual income in a blue chip stock.
PSY23: Lending a friend the money needed to purchase a $20 toll tag so they could use the managed lane.
PSY24: Lending a friend an amount of money equivalent to one month's income.
PSY25: Betting a day's income at the horse races.
Five Questions: Retained for online survey, but only recommended for analysis at the item level (not as part of a scale). Had at least one pairwise comparison found to have mean ranks that were statistically significantly different (at a 0.05 significance level) between two modes in the Kruskal-Wallis one-way ANOVA analysis.
PSY2: Unless there is no traffic on the freeway, I choose the managed lane since traffic could become congested at any time.
PSY4: When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.
PSY10: I only choose to use the managed lane if the general purpose lane seems crowded.
PSY17: I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.
PSY20: I generally choose to use managed lanes when I feel it is the only way I will make it to my destination on time.

Table 1. continued

17 Questions: Retained in online survey for further analyses as part of scale (based on Cronbach's alpha and EFA analyses).
Three Questions: Retained in online survey because interesting.
PSY3: If I were listening to the radio and heard there is an accident on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.
PSY6: I usually choose to use the managed lane only at the last second, after observing freeway traffic for as long as I can.
PSY11: I rarely complain about traffic problems because that will not help fix the problem.

[+] Indicates that this psychological item did NOT have at least one Kruskal-Wallis one-way ANOVA pairwise comparison that had a distribution found to be statistically significantly different (at a 0.05 significance level) between two modes.
[R] Indicates that this psychological item was reverse scored for the scale analyses.

5.6. Survey Design

The data used in this research effort were collected in a similar manner as described in Burris et al. (2012a). Roughly half of the respondents were given a survey based on a DBE design and half were given a survey based on an AR design. More detail on these two survey design types is provided in the following subsections.

5.6.1 D_b-Efficient Design

As mentioned in the literature review, DBE surveys require input known as "priors". In order for the design to more realistically reflect the characteristics associated with the survey locations, information such as distance, toll rate, and average speed associated with the original eight freeways in question was gathered. This information was used in establishing the value of the priors. The values of the priors were then input into the computer program, Ngene, allowing for the ultimate creation of five different blocks, each consisting of three rows of data (one row for each of the three SP questions).

The mean, standard deviation of attribute priors, and attribute levels for different times of day are provided in Table 2 (Florence 2014).

Table 2. Mean and Standard Deviation of Attribute Priors, and Attribute Levels for Different Times of Day

Attribute	**Attribute Levels**				**Mean Value of Priors**	**Standard Deviation of Priors**
	Mode	**Time of Day**				
		Peak Hours	**Shoulder Hours**	**Off-Peak Hours**		
Toll (cents/mile)	**CP-ML**	0	0	0	-0.12	0.10
	DA-ML	45,67.5,90	22.5,33.75,45	15,22.5,30		
	CP-GPL	0	0	0		
	DA-GPL	0	0	0		
Speed (mph)	**CP-ML**	55,60,65	55,60,65	60,65,70	-0.14[A]	0.64
	DA-ML	55,60,65	55,60,65	60,65,70		
	CP-GPL	25,35,45	30,40,50	35,45,55		
	DA-GPL	25,35,45	30,40,50	35,45,55		

Source: Florence 2014, p. 12

[A] Prior is the coefficient of travel time from a previous survey on ML use done by Burris et al.(2012a). Necessary transformation was performed to use it as a coefficient for speed.

In DBE design, the goal is to minimize the D_b error (i.e., get it as close to 0 as possible). The D_b error for the design used in this research was 0.09, which was deemed to be sufficiently small. See Appendix C for the Ngene code that was used in the creation of the DBE Design. The DBE design that was generated using Ngene (for peak hours) is shown in Table 3 (Florence 2014). The DBE designs for the shoulder and off peak time periods were adjusted from the peak hour values. Respondents who did not indicate the time of their most recent trip on the EL corridor in question were assigned to either the AM or PM peak.

Table 3. D_b-Efficient Design Generated Using Ngene (For Peak Hours)

Mode	CP-ML	DA-ML		CP-GPL	DA-GPL	Block
Choice Situation	Speed (mph)	Speed (mph)	Toll (cents/ mile)	Speed (mph)	Speed (mph)	
1	60	60	90	35	35	1
2	55	55	67.5	35	35	1
3	65	65	67.5	35	35	1
4	65	65	45	25	25	2
5	55	55	45	45	45	2
6	60	60	90	45	45	2
7	55	55	45	35	35	3
8	65	65	67.5	25	25	3
9	60	60	67.5	25	25	3
10	60	60	45	45	45	4
11	55	55	90	45	45	4
12	65	65	90	25	25	4
13	55	55	67.5	45	45	5
14	60	60	45	25	25	5
15	65	65	90	35	35	5

Source: Florence 2014, p. 13

5.6.2 Adaptive Random Design

The surveys associated with the AR design differ from the DBE design. In the DBE design the travel time and toll values for all three SP questions were assigned to a respondent when they began taking the survey. Under the AR design, toll values shown for subsequent SP questions were influenced by how respondents answered the previous

SP question(s). If a respondent selected a toll option for their previous SP question response, the toll value shown in the next SP question increased in the range of 15% to 75%. On the other hand, if they did not choose a toll option for their previous SP question response, the toll value shown for their next SP question decreased in the range of 15% to 50%. The initial attribute level ranges used for the AR design are shown in Table 4 (Florence 2014).

Table 4. Initial Attribute Levels for the AR Design

Attribute	Attribute Levels			
	Mode	Time of Day		
		Peak Hours	Shoulder Hours	Off-Peak Hours
Toll (cents/mile)	CP-ML	0	0	0
	DA-ML	45+(0 to 45)	22.5+(0 to 22.5)	15+(0 to 15)
	CP-GPL	0	0	0
	DA-GPL	0	0	0
Speed (mph)	CP-ML	55+(0 to 10)	55+(0 to 10)	60+(0 to 10)
	DA-ML	55+(0 to 10)	55+(0 to 10)	60+(0 to 10)
	CP-GPL	25+(0 to 20)	30+(0 to 20)	35+(0 to 20)
	DA-GPL	25+(0 to 20)	30+(0 to 20)	35+(0 to 20)

Source: Florence 2014, p. 14

For comparison purposes, the ranges for the initial toll shown were identical for the DBE and AR designs. For the AR design, if a respondent selected a tolled option for SP1, the survey was programmed to not allow the toll rate to exceed $1 per mile ($10 total toll) for SP2 and SP3. In terms of a minimum allowable toll rate for the AR design, SP2 and SP3 were not allowed to have a toll rate lower than 10 cents per mile.

For the AR design, the toll rate associated with SP1 was in the range of 45 to 90 cents per mile. An adjustment to this initial toll rate range was made for respondents from Seattle, SLC, and Minn. The actual tolls in these study areas are noticeably lower than those in the other three study areas (LA, DC, and Atlanta). Thus, the initial toll rate applied to respondents in Seattle and Minn were reduced by 15 percent, and the initial toll rate applied to respondents in SLC was reduced by 33.3 percent. The values associated with the DBE design were also reduced by 15 percent or 33.3 percent for the appropriate study areas. However, if respondents in these cities selected a tolled option, subsequent SP questions were still permitted to go as high as $1 per mile for the AR design. This maximum allowable rate of $1 for the AR design was the same across all study areas, because even though it is higher than the toll rates currently experienced in some of the lower toll priced study areas (i.e., Seattle, SLC, and Minn), the information received on how respondents respond to higher tolls may be of interest to transportation professionals in these areas. All toll values displayed in the survey to respondents were rounded to the nearest nickel.

The minimum distance a respondent was tolled for was 6 miles and the maximum distance a respondent was tolled was 10 miles—with one of these two distances being used in the calculation of the SP toll. Specifically, if the reported length of the respondent’s most recent trip on the local EL corridor in question was less than 6 miles, then the toll value shown for the SP questions was 6 (miles) times the appropriate toll rate ($/mile). If the length of the trip was 6 miles or greater, then the toll value shown for the SP questions was 10 times the appropriate toll rate.

In terms of calculating the travel time values for the alternatives shown in the SP questions, trips that were less than 6 miles were considered to be 6 miles. For all other trip lengths (i.e., 6 to 10 miles, 11 to 15 miles, 16 to 20 miles, etc.), the travel time was calculated using the appropriate speed and maximum distance within the range. The only exception to this rule was for the open-ended length category of "More than 30 miles", in which case the travel time was calculated using 35 miles as the distance traveled.

For instance, if respondents indicated that they traveled 16-20 miles, the travel time was calculated using 20 miles as the distance. If the assigned GPL speed for that SP question scenario was 40 mph, the travel time shown for the GPL alternatives would be 30 minutes. The travel time associated with the EL alternatives was calculated in like manner. Note that for a given SP question, the speed on the GPL was never allowed to be higher than the speed on the EL. During the peak period, the speed on the EL was always as least 10 mph higher than the speed on the adjacent GPL.

5.7. Data Collection and Advertising

The survey, including the new psychological items, was programmed into LimeSurvey to allow for web-based data collection. Code used in the survey performed by Burris et al. (2012a) was used as a starting point. Prior to making the survey available to potential respondents, the survey was pilot tested by two Texas A&M students to pinpoint any potential issues to be addressed and fixed prior the actual data collection. These two students were timed in how long it took them to complete the survey so that a more accurate estimate of how long the survey was anticipated to take could be included in survey advertisements.

The survey (see Appendix D) was online for approximately seven weeks, from the end of July 2014 until September 15, 2014. Efforts were made to work with local transportation agencies in each of the survey areas to promote the survey. Advertisements specific to each study area were created and given to the transportation professional point of contact for each area. As an example, the small and large advertisements provided to SLC are shown in Figure 10 and Figure 11 respectively.

Figure 10. Example of small advertisement.

Figure 11. Example of large advertisement.

The response rate in each study area had ties to the level at which the survey was advertised in a given study area. This was partially, but not completely, a reflection of the level of advertising help received from the transportation professional points of contact. Thanks to advertisements in electronic newsletters, there was a good response in SLC and Minn (over 2,000 respondents in each city). However, despite the survey being advertised via electronic newsletter in the DC area as well, the result was not nearly as large of a response as that seen in SLC and Minn. This is likely due to the smaller number of subscribers to the DC area electronic newsletter.

Although other methods of advertisement (including Facebook and Twitter), were used in advertising the survey, these methods did not appear to be nearly as effective in helping to recruit respondents as the electronic newsletter method. Screenshots of some of the Twitter and Facebook advertisements that were created are provided in Figure 12 and Figure 13, and Figure 14, respectively. For a list of avenues used to advertise the survey, see Appendix E.

5.8 Selecting the Winners

After completing the survey itself, respondents were given the opportunity to provide their contact information, to be entered into a drawing for one of five $250 MasterCard gift cards. One gift card winner was selected from each survey location. The winners were selected through a random drawing that took place on September 25th in the CE/TTI Building on the Texas A&M campus. Each respondent who completed the survey and provided their contact information was assigned a number. The data were cleaned to remove any obvious duplicates. Likewise, a search of the provided email addresses was performed, and persons potentially working for a Department of Transportation (DOT) or a local toll authority were identified. These names were highlighted so that a further inquiry of their eligibility to win the gift cards could be performed should their name be selected as a winner.

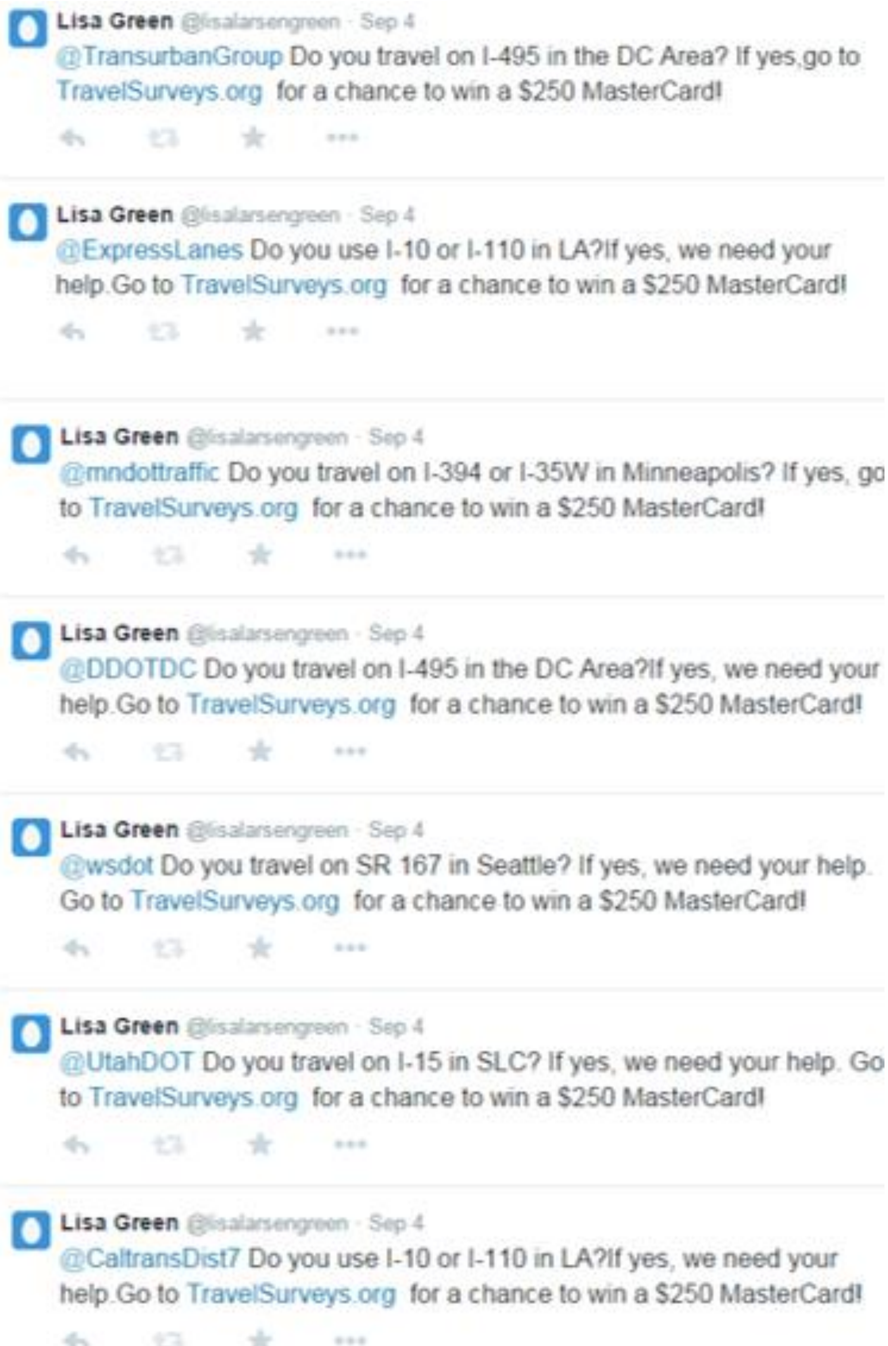


Figure 12. Example Twitter advertisements.

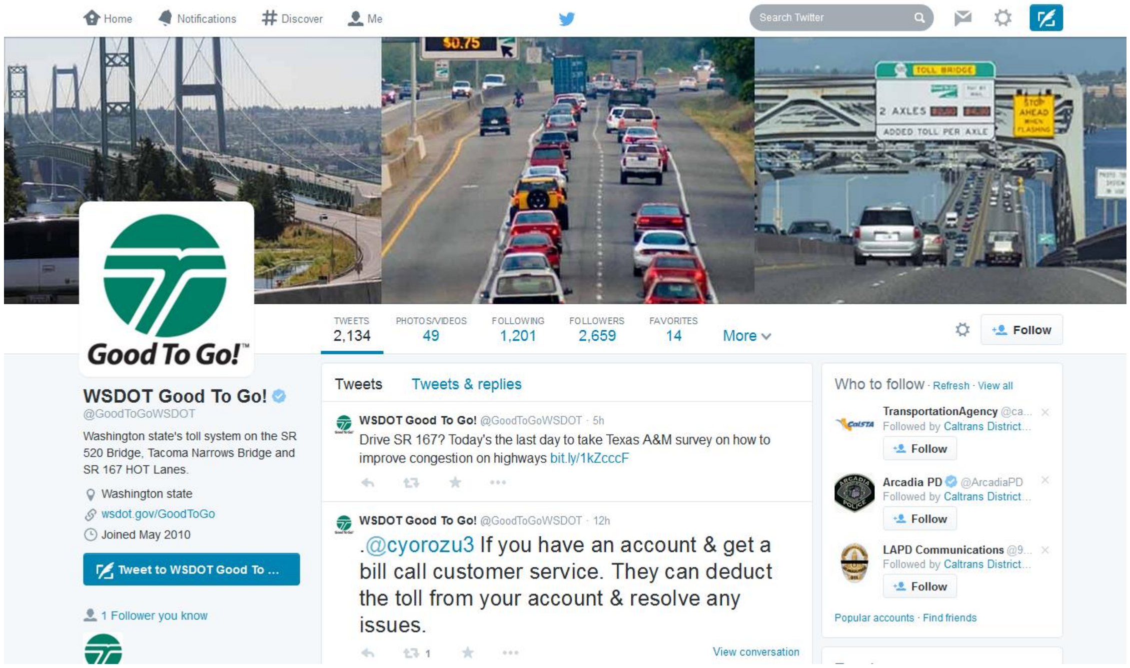


Figure 13. Additional example Twitter advertisement.

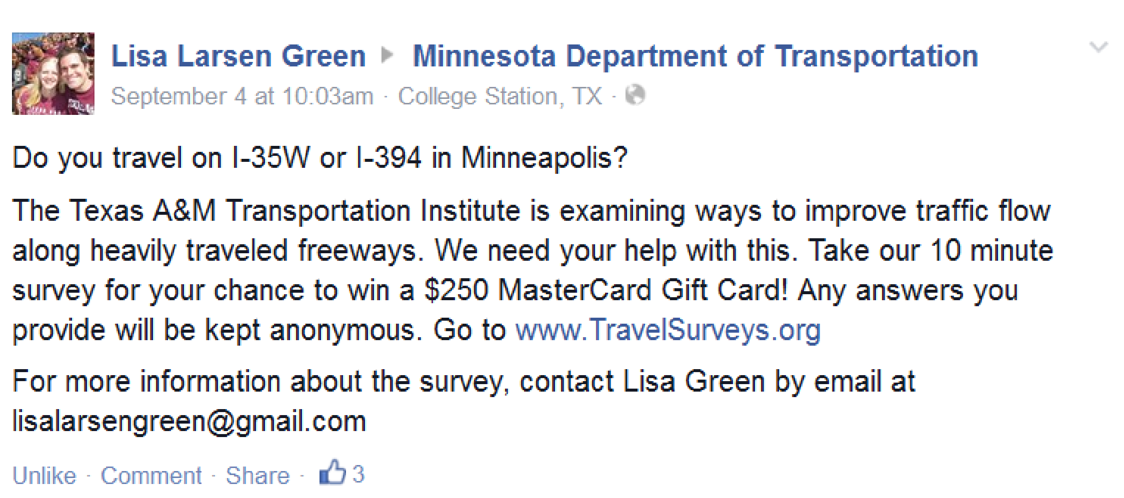


Figure 14. Example Facebook post.

None of the selected winners were associated with the highlighted names, so concern for this potential issues was minimal. However, upon contacting each of the winners, it was double-checked that none of them worked for a DOT or local toll authority. Respondents were assigned a number and then a random numbers were drawn to determine the winner from each study area.

5.9 Cleaning the Data

The window of opportunity to complete the survey ended at 11:59:59 pm on September 15, 2014. The next morning (September 16th), the survey website changed to where people were thanked for their interest in the survey but told that the survey was closed. Three respondents completed the survey within the window of approximately eight hours between when the survey closed and when the website indicated that people could no longer take the survey. These respondents were removed from the survey sample prior to data analysis.

Surveys were labeled as “complete” or “incomplete” by LimeSurvey. Upon examining the incomplete data, it was determined that these survey responses were missing enough key data that they would not be of use in the present study. Thus, only the “complete” data were considered for inclusion in the final sample. The original sample size of “complete” data consisted of 4,830 respondents. As mentioned in the preceding paragraph, three of these surveys were removed because they were completed after the survey deadline.

One of the variables was the IP Address of the computer used to complete the survey. The responses associated with a duplicate IP Address were considered on a case-by-case basis. Based on the survey answers, most of these respondents were deemed to be different persons using a public access computer, computers with the same IP address at work, or different family members using the same computer. However, seven of the surveys were deleted from the survey sample. For these seven deleted surveys, a duplicate existed (and was retained in the survey sample) that had identical demographic information (excepting, in some cases where one of the surveys had missing information). In addition, the deleted surveys were found to either have very similar responses for the psychological items and/or start time of the two surveys that were close to each other. In such cases, the survey with the most data available (i.e., least missing items) was retained.

The first four responses (received between July 22, 2014 and July 29, 2014) were thought to be responses obtained from people testing the survey, so they were removed. Additionally, as mentioned previously, survey respondents were recruited from five study areas (Seattle, SLC, LA, DC, and Minn). However, only two respondents were from LA, only five respondents (remaining after filtering was performed to this point) were from Seattle, and 18 respondents (remaining after filtering was performed to this point) were not from one of the five study areas in question or did not specify their study area. Given the low sample sizes obtained in these three study area categories, the surveys associated with LA, Seattle, and none of the five specified cities/didn't specify, were removed from the sample. Note that the large variation in sample size was largely linked to the level of advertising assistance provided by the local transportation points of contact. An electronic newsletter was not sent out in the LA or Seattle areas, which had clear ties to the low sample sizes in these areas.

Lastly, only those respondents who indicated that the type of vehicle they used on their most recent trip on the local ML corridor in question fell into the category of "Passenger car, SUV, or pick-up truck" were of interest. Thus, respondents who indicated that they had used either a motorcycle of a bus for their most recent trip on the local EL corridor in question were removed from the survey. Those modes are generally allowed on the ELs for free and there were too few of them to analyze as a separate group. A summary of the surveys removed from the sample that was analyzed in the present study is provided in Table 5.

Table 5. Description of Surveys Removed

Study Area	All	Seattle	SLC	LA	DC	Minn	None of these cities/ Didn't Specify
Completed the Survey	4,830	6	2,063	2	82	2,657	20
Completed the Survey after 9/15/14 deadline	3	-	-	-	-	3	-
Remaining Number of Surveys	4,827	6	2,063	2	82	2,654	20
Considered to be duplicate based on IP address	7	-	3	-	-	3	1
Remaining Number of Surveys	4,820	6	2,060	2	82	2,651	19

Table 5. continued

Study Area	All	Seattle	SLC	LA	DC	Minn	None of these cities/ Didn't Specify
Responses thought to be those of testers (first four responses received between 7/22 and 7/29)	4	1	-	-	-	2	1
Remaining Number of Surveys	4,816	5	2,060	2	82	2,649	18
Only include respondents from SLC, Minn, and DC	25	5	-	2	-	-	18
Remaining Number of Surveys	4,791	0	2,060	0	82	2,649	0
Only include vehicle types of Passenger car, SUV, or pick-up truck (remove those who used a motorcycle or bus for their most recent trip on the local ML corridor in question)	79	-	28	-	4	47	-
Final Sample Sizes for Analysis	4,712	0	2,032	0	78	2,602	0

At this point, some additional variables were created to assist in filtering the data to eliminate any data that may not be meaningful or useful for a specific analysis. Although several variables were created for potential use, ultimately only RHHSIZE, RHHVEH, and RNUMWWTR were actually used as filters (when appropriate) in the discrete choice modeling process. The filters were applied during analyses of models involving these variables, which meant that the affected respondents were not included in models when that filter was applied. Different respondents were affected by these three filters. A summary of these three filters, along with the number of respondents affected by the filter, is provided in Table 6.

Table 6. Filter Variables

Created Filter Variable	**Description of Which Respondents are Flagged**	**Number of Respondents Affected by Filter**
RHHSIZE	The household size was reported to be greater than 20 people, or equal to 0.	14
RHHVEH	The number of household vehicles was reported to be greater than 10 vehicles.	11
RNUMWWTR	The total number of work week trips made on the local EL corridor during the last full work week was reported to be more than 60 trips.	3

In summary, the data analysis that is described in Chapter 6 included data obtained from 4,712 respondents (2,032 respondents from SLC; 78 respondents from DC; and 2,602 respondents from Minn). Each respondent was asked to answer three stated preference questions related to travel on a local EL corridor, and were also asked to respond to 25 psychological items. Although some respondents did not respond to some of the psychological items, each respondent did respond to three stated preference questions—resulting in 14,136 SP question responses being obtained. See Chapter 6 for the details surrounded the analyses of these data.

6. DATA ANALYSIS AND RESULTS

Once the data were properly cleaned and formatted, the next step was to analyze the data. The analyses performed fell into one of the following six categories:

- Summary by Study Area (Section 6.1)
- SP Responses based on Demographic Data, Trip Information, and Psychological Items (Section 6.2)
- Preliminary Statistical Tests/Related Issues (Section 6.3):
  - Tests
    - ANOVA (Analysis of Variance) Test Procedures (Subsection 6.3.1)
    - Kruskal-Wallis Test Procedures (Subsection 6.3.2)
    - Ordinal Regression Models (logit links) (Subsection 6.3.3)
  - Related Issues
    - Correlations (Section 6.3.4)
- Mixed Logit Models (Section 6.4)
  - Trip and Demographic Characteristic Models (Subsection 6.4.2)
  - Psychological Item Models (Subsection 6.4.3)
  - Psychological Scale Models (Subsection 6.4.4)
  - Combined Models (Trip and Demographic + Psychological Items or Trip and Demographic + Psychological Scales) (Subsection 6.4.6)
- Impact of Income on the VTTS (Section 6.5)

- Survey Design: Comparing DBE and AR Designs (Section 6.6)

The following sections will discuss these analyses, and their accompanying findings.

6.1 Summary by Area

A summary of the date the surveys used in this analysis were obtained is provided in Figure 15. Roughly two thirds of the useable surveys for each of the three study areas (SLC, DC, and Minn) were obtained on a given day—which is closely linked to when pushes to advertise the survey were made via electronic newsletter.

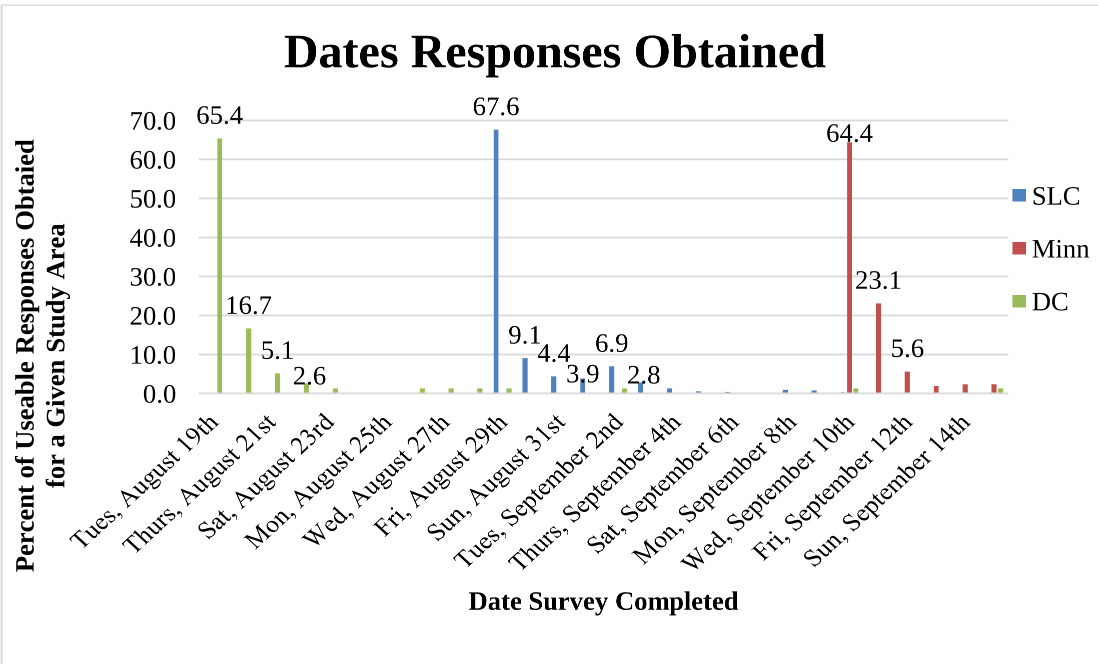


Figure 15. Surveys by response data for data included in the analysis sample.

Prior to performing statistical tests or creating discrete choice models, the data from SLC, DC, and Minn were summarized both individually and collectively. This provided a good initial overview of the data, though in-and-of itself not being very useful in guiding further analysis. An overview of key trip information, by study area, is provided in Table 7.

Table 7. Overview of Trip Information

Characteristic	**Study Area**			
	SLC	**DC**	**Minn**	**All (SLC, DC, and Minn)**
TRIP INFORMATION				
Trip Purpose of Most Recent Trip on EL Corridor in Question (Shown as a percentage of the respondents from a given study area, %.)				
Commuting (going to or from work)	73.7	48.7	76.4	74.8
Recreational/Social/Shopping/Entertainment/ Personal Errands	11.3	30.8	10.6	11.2
School	0.9	0.0	1.3	1.1
Work Related (other than between home and work)	11.8	11.5	9.7	10.6
Didn't Specify/Other	2.3	9.0	2.0	2.3
Day of Week of Most Recent Trip on EL Corridor in Question (Shown as a percentage of the respondents from a given study area, %.)				
Sunday	1.5	2.5	1.3	1.4
Monday	6.0	16.7	10.1	8.4
Tuesday	8.9	30.8	21.6	16.3
Wednesday	11.9	16.7	40.0	27.5
Thursday	32.7	12.8	15.3	22.8
Friday	35.9	15.4	9.6	21.0
Saturday	3.0	5.1	1.8	2.4
Didn't Specify	0.1	0.0	0.3	0.2

Table 7. continued

Characteristic	Study Area			
	SLC	DC	Minn	All (SLC, DC, and Minn)
Length of Trip (Shown as a percentage of the respondents from a given study area, %.)				
Less than 2 miles	0.2	1.3	0.4	0.3
3 to 5 miles	0.9	3.8	4.4	2.9
6 to 10 miles	4.8	10.2	15.4	10.8
11 to 15 miles	10.5	16.7	22.3	17.1
16 to 20 miles	15.0	15.4	18.7	17.0
21 to 25 miles	14.5	7.7	16.8	15.6
26 to 30 miles	14.4	15.4	9.0	11.5
More than 30 miles	39.3	28.2	12.8	24.5
Didn't Specify	0.4	1.3	0.2	0.3
Number of People (including yourself) in the Passenger Car/SUV/Pick-up Truck (Shown as a percentage of the respondents from a given study area, %.)				
1	83.1	64.1	89.3	86.2
2	11.9	16.7	8.8	10.2
3	2.2	11.5	0.7	1.5
4	1.6	5.1	0.5	1.1
5+	0.7	2.6	0.2	0.5
Didn't Specify	0.5	0.0	0.5	0.5
Were you the driver or a passenger on this recent trip? (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck, who responded to this question. Shown as a percentage of the respondents from a given study area, %.)				
Driver	83.3	75.0	81.2	82.0
Passenger	16.7	25.0	18.8	18.0
Who did you travel with on this recent trip? (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%. Shown as a percentage of the respondents from a given study area, %.)				
Co-worker/person in the same, or a nearby, office building	28.9	17.9	19.5	24.4
Neighbor	2.4	7.1	3.1	2.9
Adult family member	55.9	64.3	56.3	56.5
Child	19.8	39.3	24.1	22.5
Other	6.7	0.0	7.3	6.6

Table 7. continued

Characteristic	Study Area			
	SLC	DC	Minn	All (SLC, DC, and Minn)
How much extra time did it take to pick up and drop off the passenger(s)? (minutes) (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck, who responded to this question. Shown as a percentage of the respondents from a given study area, %.)				
0	47.5	80.0	53.7	51.4
1-5	19.0	10.0	23.6	20.6
6-10	15.6	0.0	8.9	12.1
11-15	6.1	0.0	7.9	6.6
16-20	6.5	5.0	1.5	4.3
21-30	3.0	0.0	1.0	2.1
31-60	1.5	5.0	2.9	2.3
Greater than 60 (but less than 120)	0.4	0.0	0.5	0.4
Unrealistic (120)	0.4	0.0	0.0	0.2
Did you use the EL for that trip? (Shown as a percentage of the respondents from a given study area, %.)				
Yes	67.1	62.8	69.6	68.4
No	32.6	37.2	30.3	31.4
Didn't Specify	0.3	0.0	0.1	0.2
How much travel time do you think you saved (by using the EL) compared to the GPLs? (minutes) (Calculated based on those who indicated they used the EL for that trip, who responded to this question. Shown as a percentage of the respondents from a given study area, %.)				
0	3.1	0.0	1.3	2.0
1-5	36.6	16.3	23.2	28.8
6-10	29.1	16.3	30.7	29.8
11-15	17.3	24.5	21.1	19.5
16-20	7.6	24.5	13.5	11.2
21-30	5.1	10.2	7.3	6.5
31-60	1.1	8.2	2.8	2.1
Unrealistic (more than 60 minutes)	0.1	0.0	0.1	0.1
Have you ever used the EL on the EL corridor in question? (Calculated based on those who responded to the question. Shown as a percentage of the respondents from a given study area, %.)				
Yes	99.9	92.8	99.3	99.4
No	0.1	7.2	0.7	0.6

Table 7. continued

Characteristic	Study Area			
	SLC	DC	Minn	All (SLC, DC, and Minn)
What are the main reasons you used the EL? (Calculated based on those who said they had used the EL. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%. Shown as a percentage of the respondents from a given study area, %.)				
Being able to use the EL for free as a carpool	28.5	25.0	20.4	24.0
During the peak hours the ELs will not be congested	59.2	62.5	67.7	64.0
Travel times on the ELs are consistent and predictable	26.6	64.1	46.0	37.9
The ELs are safer/less stressful than driving on the GPLs	42.6	56.3	44.6	43.9
Travel times on ELs are less than those on the GPLs	87.8	75.0	99.2	93.9
Trucks and larger vehicles are not allowed on the ELs	28.7	37.5	10.1	18.5
My employer pays for the tolls	5.2	7.8	3.6	4.4
Other	5.4	14.1	3.3	4.4
Reasons you have never used the EL (Calculated based on those who said they had not used the EL. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%. Shown as a percentage of the respondents from a given study area, %.)				
Access to the Express Lanes is not convenient for my trips	0.0	80.0	25.0	34.8
The tolls are too high for me	0.0	40.0	12.5	17.4
I can easily use other routes than the Freeway, so I'll just avoid it if I think there is a lot of traffic	0.0	40.0	25.0	26.1
The Express Lanes do not offer me enough time savings	0.0	0.0	37.5	26.1
I do not want to pay the toll for this trip	0.0	60.0	43.8	43.5
I don't like that the toll changes based on time of day	0.0	40.0	6.3	13.0
I do not want a toll transponder in my car	0.0	0.0	6.3	4.3
I do not have a credit card so it is inconvenient to set up a toll account	0.0	20.0	0.0	4.3
I have the flexibility to travel at less congested times	50.0	40.0	12.5	21.7
Express lane use is complicated or confusing	0.0	0.0	12.5	8.7
Participation in a carpool is difficult/undesirable	50.0	0.0	12.5	13.0
Other	0.0	0.0	18.8	13.0

Table 7. continued

Characteristic	Study Area			
	SLC	DC	Minn	All (SLC, DC, and Minn)
How many total trips did you make during the past full work week (Monday to Friday) on [the EL corridor in question]? (Each direction of travel is one trip, include trips on the EL or GPLs. Shown as a percentage of the respondents from a given study area, %.)				
0 trips per week	2.0	10.3	2.8	2.6
1-5 trips per week	36.8	39.7	35.3	36.1
6-10 trips per week	47.9	43.6	53.7	51.0
11-15 trips per week	10.2	5.1	6.2	7.9
16-20 trips per week	2.1	1.3	1.3	1.6
21 or more trips per week (but no more than 60 trips)	0.8	0.0	0.4	0.6
Didn't Specify/Unrealistic (more than 60 trips)	0.2	0.0	0.3	0.2
How many of those Freeway trips were using the EL? (Shown as a percentage of the respondents from a given study area, %.)				
0 trips per week	10.1	23.1	8.9	9.6
1-5 trips per week	56.0	43.6	57.4	56.5
6-10 trips per week	28.1	21.8	29.7	28.9
11-15 trips per week	3.0	1.3	1.4	2.1
16-20 trips per week	0.4	0.0	0.2	0.3
21 or more trips per week (but no more than 60 trips)	0.3	0.0	0.0	0.2
Didn't Specify/Unrealistic Answer (decimal or more than 60 trips)	2.1	10.2	2.4	2.4
How many of those trips would you say you were unusually pressed for time or had a tight schedule? (Shown as a percentage of the respondents from a given study area, %.)				
0 urgent trips per week	25.8	33.3	24.7	25.3
1-5 urgent trips per week	58.6	47.4	60.4	59.4
6-10 urgent trips per week	10.7	7.7	9.5	10.0
11-15 urgent trips per week	1.2	1.3	0.4	0.8
16-20 urgent trips per week	0.2	0.0	0.2	0.2
21 or more trips per week	0.2	0.0	0.0	0.1
Didn't Specify/Unrealistic Answer (decimal)	3.3	10.3	4.8	4.2

Table 7. continued

Characteristic	Study Area			
	SLC	**DC**	**Minn**	**All (SLC, DC, and Minn)**
Think about those trips that you were pressed for time. What percentage of the time did you use the ELs for those trips? (Calculated based on % of respondents who answered this question. Shown as a percentage of the respondents from a given study area, %.)				
Never use the EL for those urgent trips	0.3	2.8	0.1	0.2
Rarely use the EL for those urgent trips	4.3	8.3	1.6	2.8
About half the time I use the EL for those urgent trips	17.9	13.9	8.6	12.7
Most of my urgent trips are on the EL	29.8	16.7	23.0	25.8
Always use the EL for those urgent trips	47.7	58.3	66.7	58.5
On average, how much did you pay for the toll for a typical trip on the EL? (Calculated based on % of respondents who answered this question. Shown as a percentage of the respondents from a given study area, %.)				
Less than $1.00	43.6	7.7	18.9	29.4
$1.01 to $3.00	35.6	36.5	54.3	46.0
$3.01 to $5.00	5.7	28.9	16.2	11.8
More than $5.00	1.6	15.4	3.3	2.7
Do not remember	7.4	3.8	4.9	6.0
$0. I am a toll free user so I did not pay a toll	6.1	7.7	2.4	4.1
Approximately how much time did you save by using the EL? (Calculated based on % of respondents who answered this question. Shown as a percentage of the respondents from a given study area, %.)				
0 minutes	1.6	0.0	0.0	0.7
1-5 minutes	23.9	11.5	13.4	17.9
6-10 minutes	29.3	17.3	24.7	26.6
11-15 minutes	15.2	21.2	21.5	18.8
16-20 minutes	9.0	21.2	13.1	11.4
21-30 minutes	7.8	7.7	9.2	8.6
31-60 minutes	7.6	7.7	10.5	9.2
More than 60 minutes (but no more than 600 minutes)	5.5	13.4	7.6	6.8
Unrealistic (more than 600 minutes)	0.1	0.0	0.0	0.0

An overview of the stated preference responses, by study area, is provided in Table 8.

Table 8. Overview of the Stated Preference Reponses

Characteristic	Study Area			
	SLC	**DC**	**Minn**	**All (SLC, DC, and Minn)**
STATED PREFERENCE RESPONSES				
Response to SP Travel Choice Question 1 (Shown as a percentage of the respondents from a given study area, %,)				
DA-GPL	44.7	35.9	49.1	47
CP-GPL	1.3	3.9	0.7	1.0
Drive Alone-Express Lane (DA-EL)	33.4	33.3	36	34.8
Carpool-Express Lane (CP-EL)	20.6	26.9	14.2	17.2
Response to SP Travel Choice Question 2 (Shown as a percentage of the respondents from a given study area, %.)				
DA-GPL	49.4	43.6	52.1	50.8
CP-GPL	1.4	1.3	0.7	1.0
DA-EL	30.0	33.3	35.1	32.9
CP-EL	19.2	21.8	12.1	15.3
Response to SP Travel Choice Question 3 (Shown as a percentage of the respondents from a given study area, %.)				
DA-GPL	48.1	39.7	49.0	48.5
CP-GPL	1.0	2.6	0.4	0.7
DA-EL	31.2	34.6	38.2	35.1
CP-EL	19.7	23.1	12.4	15.7

An overview of key demographic data, by study area, is provided in Table 9.

Table 9. Overview of Demographic Data

Characteristic	Study Area			
	SLC	DC	Minn	All (SLC, DC, and Minn)
DEMOGRAHPIC DATA				
What is your age? (Shown as a percentage of the respondents from a given study area, %.)				
16 to 24	0.7	1.3	0.9	0.9
25 to 34	17.2	10.3	14.2	15.4
35 to 44	27.7	17.9	22.6	24.7
45 to 54	25.4	26.9	30.3	28.1
55 to 64	21.7	33.3	22.5	22.3
65 and over	6.4	10.3	8.8	7.8
Didn't Specify	0.9	0.0	0.7	0.8
What is your gender? (% of respondents who answered this question. Shown as a percentage of the respondents from a given study area, %.)				
Male	66.4	61.5	49	56.7
Female	31.6	37.2	48.8	41.2
Didn't Specify	2.0	1.3	2.2	2.1
Please describe the type of household you live in. (Shown as a percentage of the respondents from a given study area, %)				
Single Adult	14.7	16.7	16.8	15.9
Unrelated adults	1.6	3.8	3.6	2.7
Married without children	20.6	24.4	21.0	20.9
Married with child(ren)	56.7	47.4	50.8	53.3
Single parent family	4.0	5.1	5.2	4.7
Other/Didn't Specify	2.4	2.6	2.6	2.5
Is your child(ren) between 5 to 17 years old (school age)? (Calculated based on % of respondents who answered this question. Shown as a percentage of the respondents from a given study area, %.)				
Yes	62.6	56.1	55.8	58.9
No	37.4	43.9	44.2	41.1

Table 9. continued

Characteristic	Study Area			
	SLC	DC	Minn	All (SLC, DC, and Minn)
Including yourself, how many people live in your household? (Shown as a percentage of the respondents from a given study area, %.)				
1	10.9	7.7	12.9	12.0
2	30.6	38.5	37.6	34.5
3	16.6	23.1	17.4	17.1
4	17.3	17.9	21.2	19.5
5+ (up to 20 people)	24.0	12.8	9.7	15.9
Didn't Specify/Unrealistic (0 people or greater than 20 people)	0.6	0.0	1.2	1.0
All together, how many motor vehicles (including cars, vans, trucks, and motorcycles) are available for use by members of your household? (Shown as a percentage of the respondents from a given study area, %.)				
1	8.9	14.1	13.2	11.3
2	39.7	48.7	49.6	45.3
3	28.0	24.4	22.5	24.9
4	14.1	6.4	8.9	11.1
5+ (but not greater than 10 vehicles)	8.5	5.1	4.5	6.2
Didn't Specify/Unrealistic (greater than 10 vehicles)	0.8	1.3	1.3	1.2
What category best describes your occupational or work status? (Shown as a percentage of the respondents from a given study area, %.)				
Professional/Managerial	52.7	56.4	58.7	56.1
Technical	12.7	14.1	7.6	9.9
Sales	7.6	0.0	7.5	7.4
Administrative/Clerical	6.1	5.1	5.5	5.7
Manufacturing	1.0	0.0	0.5	0.7
Stay-at-home homemaker/parent	0.7	1.3	0.5	0.7
Student	0.8	1.3	1.1	1.0
Self employed	7.2	6.4	6.3	6.7
Unemployed/Seeking work	0.8	1.3	0.6	0.7
Retired	3.0	8.9	3.6	3.4
Educator	2.6	2.6	3.4	3.0
Other/Didn't Specify	4.8	2.6	4.7	4.7

Table 9. continued

Characteristic	Study Area			
	SLC	**DC**	**Minn**	**All (SLC, DC, and Minn)**
What was the last year of school that you have completed? (Shown as a percentage of the respondents from a given study area, %.)				
Less than high school	0.4	1.3	0.2	0.3
High school graduate	3.8	1.3	2.1	2.8
Some college or vocational school	26.2	20.5	15.8	20.4
College graduate	40.8	30.7	47.1	44.1
Postgraduate degree	27.2	44.9	33.2	30.8
Other/Didn't Specify	1.6	1.3	1.6	1.6
What was your gross annual household income before taxes in 2013? (Shown as a percentage of the respondents from a given study area, %.)				
Less than $10,000	0.3	1.3	0.3	0.3
$10,00 to $14,999	0.3	0.0	0.3	0.3
$15,000 to $24,999	0.9	0.0	0.5	0.7
$25,000 to $34,999	2.0	1.3	1.4	1.7
$35,000 to $49,999	6.1	3.8	4.4	5.1
$50,000 to $74,999	16.5	10.2	10.5	13.1
$75,000 to $99,999	19.3	14.1	14.4	16.5
$100,000 to $199,999	38.5	50.0	39.1	39.0
$200,000 or more	12.5	16.7	25.2	19.6
It's easier to tell hourly wage rate	0.8	1.3	0.3	0.5
Didn't Specify	2.8	1.3	3.6	3.2

6.2 SP Responses Based on Demographic Data, Trip Information, and Psychological Items

Having summarized key trip information, the SP responses, and demographic information by study area, the next step was to analyze the trip and demographic variables—as well as psychological items—in relation to respondents' SP responses. This provided initial insight as to which variables may be more influential in predicting mode choice, and thus more likely to be useful in developing MMNL models. From this point forward, unless otherwise stated, tables, figures, and calculations are based on the combined data from all three SP questions for all three study areas (SLC, DC, and Minn).

A table summarizing the average Likert scale response to each psychological item, in terms of which mode they selected (i.e., DA-GPL, CP-GPL, DA-EL, OR CP-EL), is shown in Table 10. For Psychological Items 1-21, the following meanings were associated with the Likert scale:

- 1=Strongly disagree
- 2=Disagree
- 3=Somewhat disagree
- 4=Slightly disagree
- 5=Neither agree nor disagree
- 6=Slightly agree
- 7=Somewhat agree
- 8=Agree
- 9=Strongly agree

For Psychological Items 22-25, alternative Likert scale definitions were used:

- 1=Extremely unlikely
- 2=Unlikely
- 3=Somewhat unlikely
- 4=Slightly unlikely

- 5=Neither likely nor unlikely
- 6=Slightly likely
- 7=Somewhat likely
- 8=Likely
- 9=Extremely likely

Table 10. Average Likert Scale Response to Each Psychological Item, in Terms of Mode Selected

Psychological Item	DA-GPL	CP-GPL	DA-EL	CP-EL	All Selected Modes Combined
PSY1: It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time.	2.89	3.30	2.43	2.84	2.73
PSY2: Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.	4.30	4.42	5.64	4.91	4.86
PSY3: If I were listening to the radio and heard there is a major crash on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.	5.37	5.54	5.44	5.40	5.40
PSY4: When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	4.32	3.55	4.83	3.80	4.40
PSY5: I have often found that what is going to happen will happen.	5.22	5.02	5.30	5.23	5.25
PSY6: I usually choose to use the express lane only at the last second, after observing freeway traffic for as long as possible.	5.20	5.47	4.00	4.33	4.65
PSY7: Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	6.17	5.02	6.09	4.84	5.92

Table 10. continued

Psychological Item	DA-GPL	CP-GPL	DA-EL	CP-EL	All Selected Modes Combined
PSY8: Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	2.40	2.63	2.40	2.48	2.41
PSY9: I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.	2.63	2.82	2.08	2.59	2.43
PSY10: I only choose to use the express lanes if the general purpose lanes seem crowded.	6.20	6.24	4.90	5.43	5.63
PSY11: I rarely complain about traffic problems because that will not help fix the problem.	4.58	5.19	4.47	4.41	4.52
PSY12: The coordination involved with carpooling is more hassle than it is worth.	6.56	5.27	6.35	4.60	6.16
PSY13: Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	3.64	3.27	3.58	3.43	3.58
PSY14: I often look up information about traffic conditions prior to driving anywhere.	4.74	4.98	4.79	4.89	4.79
PSY15: The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	5.27	5.20	5.27	5.34	5.28
PSY16: I tend to make choices about which road to use based on the traffic I encounter.	6.10	6.04	5.90	6.02	6.02
PSY17: I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	6.31	6.62	6.22	6.42	6.30
PSY18: I listen to the radio while driving so I can get updates on traffic.	5.24	6.04	5.18	5.54	5.28
PSY19: I do not like relying on others for rides.	7.65	6.53	7.67	6.37	7.44
PSY20: I generally choose to use the express lane only when I feel it is the only way I will make it to my destination on time.	5.20	5.42	4.02	4.50	4.69

Table 10. continued

Psychological Item	DA-GPL	CP-GPL	DA-EL	CP-EL	All Selected Modes Combined
PSY21: I would choose to use the express lane, knowing there is a 50 percent chance it will not save me time.	4.83	4.84	5.54	5.25	5.15
PSY22: I would invest 10% of my annual income in a quality/blue-chip stock.	4.85	4.62	4.97	4.94	4.90
PSY23: I would lend a friend the money needed to purchase a $45 [A] toll tag so they could use the express lane.	4.47	4.64	4.84	4.68	4.63
PSY24: I would lend a friend an amount of money equivalent to one month's income.	2.88	2.73	3.08	3.00	2.96
PSY25: I would bet a day's income at the horse races.	1.56	1.66	1.73	1.55	1.62

[A] This value was set to $45 upon the request of transportation professionals in Minnesota, to more accurately reflect the cost of a toll tag. Upon making this change, respondents in all study areas were shown a toll tag price of $45 for this psychological item. Only a handful of early survey respondents would have seen the value of $20 here instead of $45.

The results displayed in Table 10 provide initial insight into those psychological items that may be useful in better predicting travel behavior in a ML context (i.e., lane choice and/or carpooling decisions). Items where the average Likert scale response is noticeably different for different alternatives may be especially insightful. However, further analysis will address possible correlations among the psychological items, while accounting for the desire to be somewhat restrictive in how many psychological items are recommended for potential use in a future survey performed by a traffic and revenue estimating firm. Thus reading too much into the results of Table 10 may be somewhat premature.

A summary of the percentage of responses associated with each mode option, stratified by trip and demographic characteristics is provided in Table 11.

Table 11. Percentage of Responses Associated with Each Mode Option, Stratified by Trip and Demographic Characteristics

Characteristic Categories	DA-GPL	CP-GPL	DA-EL	CP-EL	Total (All Modes)
Trip Purpose					
Commute	79.3	66.9	74.7	72.2	76.5
Recreational	9.6	25.6	11.7	16.2	11.5
School	1.0	0.0	1.0	2.1	1.2
Work	10.1	7.4	12.7	9.6	10.9
Total	100.0	100.0	100.0	100.0	100.0
Age					
16-24	0.7	0.0	0.9	1.3	0.9
25-34	14.9	15.3	15.0	18.8	15.6
35-44	25.7	26.0	24.9	22.4	24.9
45-54	28.7	24.4	27.3	29.6	28.3
55-64	23.1	22.9	22.7	20.2	22.5
65 and over	6.8	11.5	9.2	7.7	7.8
Total	100.0	100.0	100.0	100.0	100.0
Age (grouped)					
LOWAGE (16-34)	15.6	15.3	15.9	20.1	16.4
MIDAGE (35-54)	54.5	50.4	52.2	52.0	53.3
HIGHAGE (55+)	30.0	34.4	31.9	27.9	30.3
Total	100.0	100.0	100.0	100.0	100.0
Child Age					
Yes-School Age Child(ren)	60.5	51.7	58.2	55.8	58.9
No-Child(ren) Not School Age	39.5	48.3	41.8	44.2	41.1
Total	100.0	100.0	100.0	100.0	100.0
Gender					
Male	60.4	60.2	54.5	57.6	58.0
Female	39.6	39.8	45.5	42.4	42.0
Total	100.0	100.0	100.0	100.0	100.0

Table 11. continued

Characteristic Categories	DA-GPL	CP-GPL	DA-EL	CP-EL	Total (All Modes)
Household Type					
Single adult	15.8	8.5	18.4	14.1	16.3
Unrelated adults	2.8	0.8	3.0	2.6	2.8
Married w/o children	21.5	20.9	20.3	23.5	21.4
Married w/ children	55.4	61.2	53.3	54.8	54.6
Single parent family	4.5	8.5	5.0	5.1	4.8
Total	100.0	100.0	100.0	100.0	100.0
Education					
Less than high school	0.3	0.0	0.4	0.3	0.3
High school graduate	2.8	1.5	2.9	3.2	2.9
Some college or vocational school	20.2	23.1	20.7	21.7	20.7
College graduate	46.1	43.1	43.7	43.4	44.8
Postgraduate degree	30.6	32.3	32.3	31.4	31.3
Total	100.0	100.0	100.0	100.0	100.0
Education (grouped)					
LOWEDUC (Less than high school/ High school graduate)	3.1	1.5	3.3	3.5	3.2
MIDEDUC (Some college or vocational school/College graduate)	66.3	66.2	64.5	65.1	65.5
HIGHEDUC (Postgraduate degree)	30.6	32.3	32.3	31.4	31.3
Total	100.0	100.0	100.0	100.0	100.0
Household Income					
Less than $10,000	0.3	0.8	0.2	0.7	0.4
$10,000 to $14,999	0.2	0.0	0.3	0.5	0.3
$15,000 to $24,999	0.5	1.5	0.8	1.1	0.7
$25,000-$34,999	1.9	5.4	1.2	1.9	1.7
$35,000 to $49,999	5.2	7.7	5.3	5.7	5.3
$50,000-$74,999	14.3	6.2	12.4	14.6	13.6
$75,000-$99,999	16.6	23.8	16.7	19.6	17.2
$100,000 to $199,999	42.2	40.0	38.3	40.4	40.5
$200,000 or more	18.9	14.6	24.8	15.5	20.3
Total	100.0	100.0	100.0	100.0	100.0
Household Income (grouped)					
LOWINC (Less than $25,000)	1.0	2.3	1.3	2.3	1.3
LMIDINC ($25,000-$49,999)	7.1	13.1	6.5	7.6	7.0
HMIDINC ($50,000-$99,999)	30.8	30.0	29.1	34.2	30.8
HINC ($100,000 or more)	61.1	54.6	63.1	55.8	60.9
Total	100.0	100.0	100.0	100.0	100.0

Table 11. continued

Characteristic Categories	DA-GPL	CP-GPL	DA-EL	CP-EL	Total (All Modes)
HHSIZE					
1	11.5	9.4	14.0	9.9	12.1
2	34.8	42.2	34.8	34.8	34.9
3	16.9	15.6	17.5	18.1	17.3
4	20.1	20.3	18.8	19.8	19.6
5-20	16.6	12.5	14.9	17.3	16.1
Total	100.0	100.0	100.0	100.0	100.0
HHNUMVEH					
0	0.0	0.0	0.0	0.0	0.0
1	11.1	11.7	12.8	9.8	11.5
2	46.2	48.4	44.6	47.4	45.8
3	25.7	34.4	24.5	24.3	25.2
4	10.7	4.7	11.8	11.7	11.2
5-10	6.3	0.8	6.2	6.8	6.3
Total	100.0	100.0	100.0	100.0	100.0
OCC					
1=Professional/Managerial	60.6	60.9	58.3	54.5	58.9
2=Technical	10.5	7.8	9.3	12.8	10.4
3=Sales	7.9	8.6	8.3	6.1	7.8
4=Administrative/Clerical	5.9	7.0	5.2	8.1	6.0
5=Manufacturing	0.9	2.3	0.6	0.5	0.7
6=Stay-at-Home Homemaker/Parent	0.3	0.8	0.8	1.4	0.7
7=Student	0.9	0.8	1.0	1.4	1.0
8=Self Employed	6.4	3.9	8.5	6.1	7.0
9=Unemployed/Seeking Work	0.7	0.0	0.6	1.0	0.7
10=Retired	3.1	6.3	3.7	4.8	3.6
11=Educator	2.8	1.6	3.6	3.4	3.2
Total	100.0	100.0	100.0	100.0	100.0
DAYWEEK					
1=Sunday	1.5	9.2	1.1	1.5	1.4
2=Monday	8.1	9.2	9.2	8.0	8.5
3=Tuesday	15.9	13.7	17.5	15.0	16.3
4=Wednesday	28.7	19.1	27.0	25.7	27.5
5=Thursday	23.1	16.0	22.3	23.6	22.8
6=Friday	20.5	24.4	20.8	23.1	21.1
7=Saturday	2.2	8.4	2.0	3.0	2.4
Total	100.0	100.0	100.0	100.0	100.0

Table 11.continued

Characteristic Categories	DA-GPL	CP-GPL	DA-EL	CP-EL	Total (All Modes)
DAYWEEK (grouped)					
Weekday (Mon-Fri)	96.3	82.4	96.8	95.5	96.2
Weekend (Sat and Sun)	3.7	17.6	3.2	4.5	3.8
Total	100.0	100.0	100.0	100.0	100.0
LENGTH					
1=Less than 2 miles	0.3	2.3	0.3	0.2	0.3
2=3 to 5 miles	3.1	2.3	3.1	1.7	2.9
3=6 to 10 miles	11.6	4.6	10.6	9.0	10.8
4=11 to 15 miles	18.0	13.7	17.2	14.9	17.2
5=16 to 20 miles	17.9	15.3	16.4	16.0	17.1
6=21 to 25 miles	16.4	14.5	15.0	14.9	15.7
7=26 to 30 miles	10.6	19.8	11.7	13.5	11.5
8=More than 30 miles	22.0	27.5	25.7	29.9	24.6
Total	100.0	100.0	100.0	100.0	100.0
LENGTH (grouped)					
SHORTTRP (10 miles or less)	15.1	9.2	14.0	10.9	14.0
MIDTRP (11 to 20 miles)	35.9	29.0	33.6	30.9	34.3
LONGTRP (More than 20 miles)	49.0	61.8	52.3	58.2	51.8
Total	100.0	100.0	100.0	100.0	100.0
NUMWWTRP					
0 trips per week	2.3	8.4	2.7	3.0	2.6
1-5 trips per week	33.2	42.7	36.8	43.3	36.1
6-10 trips per week	53.9	39.7	50.8	43.9	51.1
11-15 trips per week	8.2	7.6	7.7	7.7	8.0
16-20 trips per week	1.9	0.0	1.5	1.3	1.7
21 or more trips per week (but no more than 60 trips)	0.5	1.5	0.6	0.8	0.6
Total	100.0	100.0	100.0	100.0	100.0
VEHOCC					
1	92.8	58.0	90.7	60.5	86.6
2	5.5	26.0	7.4	30.0	10.3
3	0.7	4.6	1.0	5.3	1.6
4	0.6	9.2	0.7	2.8	1.1
5+	0.4	2.3	0.2	1.4	0.5
Total	100.0	100.0	100.0	100.0	100.0

Looking at the results displayed in Table 11, it seems that females had a higher likelihood of selecting an EL alternative than males. Those in the highest household income group ($200,000 or more) had a higher likelihood of selecting a drive alone alternative than a carpooling alternative, and in particular had a higher likelihood of selecting the DA-EL alternative. A similar result is observed for the more aggregated household income groups for respondents with a household income of $100,000 or more. Respondents who reported that their most recent trip on the local EL in question was a long trip (more than 20 miles) had a higher likelihood of selecting a carpooling alternative. In terms of number of trips made on the local EL corridor in question during the last full work week, those respondents who indicated that they had made 6-10 trips had a higher likelihood of selecting a drive alone alternative. This makes sense given that most of the respondents in this category (over 88% of those making 6-10 trips, and over 93% of those making 10 trips) correspond with trips to and from work (commute trips) during the weekdays. However, those who indicated that they had made only 1-5 trips had a higher likelihood of selecting a carpooling alternative. Not surprisingly, those respondents who indicated that there were two or more vehicle occupants during their most recent trip on the local EL in question had a higher likelihood of selecting a carpooling option. Keep in mind that the trends from Table 11 are preliminary in nature, and a more in-depth, statistically based analysis was performed via discrete choice modeling which will be further discussed in later sections within this chapter.

6.3 Statistical Tests: Comparison of Psychological Item Responses across Mode

Having summarized the data and considered cross tabs of the SP responses versus key trip and demographic characteristics, as well as psychological items, the next step was to perform some *exploratory* statistical tests to gain further insight into potentially useful variables for predicting mode choice based on differences in psychological item responses across the different modes. Three different types of statistical tests were performed; namely ANOVA test procedures, Kruskal-Wallis test procedures, and an ordinal regression analysis with a logit link. The ANOVA test procedures involved pre- and post hoc tests, and the Kruskal-Wallis test procedures involved post hoc tests. The ANOVA test procedures and ordinal regression analysis with a logit link considered differences in mean responses to psychological items by mode, while post hoc tests associated with the Kruskal-Wallis test procedures allowed for pairwise comparisons of the distributions associated with the mean rank of the psychological items by mode. It was anticipated that all three tests would yield similar results. This was largely the case. The related issue of correlation is also addressed in this section.

Each survey respondent answered three SP questions. With 4,712 respondents providing useable data, that equated to 14,136 SP responses being obtained. Within NLOGIT (Greene (c) 1986-2012) it is possible to specify how many SP responses were obtained from each respondent—thereby eliminating the bias that would be associated with the sample merely being treated as if were three times as large. However, some bias is likely present in the three types of statistical tests performed in this section, given the fact that the SP responses were treated as if each one was obtained from a unique individual. While these tests may not be completely valid or justified they were still deemed insightful. These statistical tests were of an exploratory nature for determining which variables were most likely to help predict mode choice, and not intended to be a final test of whether or not psychological item response varied significantly by mode. Within the following subsections, further details are provided on how each test was performed, and the results that were obtained from the exploratory analyses.

6.3.1 ANOVA Test Procedures (to compare the mean psychological item response by mode)

The first type of statistical test performed germane to comparing the psychological item means in terms of mode selected was a one-way ANOVA test (and its accompanying pre and post hoc tests) (Devore 2008; Laerd Statistics 2015b). Note that while the data did not strictly fit the mold generally associated with a one-way ANOVA test, they did not exactly coincide with a repeated measures ANOVA either. Although the analyses presented here were performed germane to one-way ANOVA, bear in mind that not all of the assumptions associated with these test procedures were met. The results of these statistical tests were *exploratory* in nature, and viewed accordingly.

The test statistic associated with the one-way ANOVA test procedures is the F test statistic. The need for ANOVA pretests relates to checking if the appropriate assumptions are met, while the need to perform post hoc tests stems from the ANOVA test being "omnibus". As explained by Laerd Statistics (2015b), "an omnibus test statistic…cannot tell you which specific groups were significantly different from each other; it only tells you that at least two groups were different." Thus, the need for post hoc tests to gain further insight into the psychological item means and how they compare across SP question mode.

A Levene's test was performed to check for homogeneity of the variance of each psychological item. The null hypothesis was that the variances were homogeneous. As long as the null hypothesis was not rejected then an ANOVA test was performed. If the Levene's test null hypothesis was rejected then a Welch ANOVA test was performed (rather than just the ANOVA test). Depending on the results of the appropriate ANOVA or Welch ANOVA test, corresponding post hoc tests were performed where appropriate.

If the ANOVA test resulted in the null hypothesis that the variances were the same being rejected, then the post hoc Tukey's test was performed. Because the group sizes were unequal, SPSS used the harmonic mean of the group sizes as a type of modification to Tukey's test (IBM Corp. (c) 1989, 2013). The Tukey's test results indicated which psychological item means were statistically different across the four mode choices. If the ANOVA test resulted in failing to reject the null hypothesis that the variances were the same, no post hoc test was needed.

In similar fashion, if the Welch ANOVA test resulted in the null hypothesis that the variances were the same being rejected, a post hoc Games-Howell Test was performed (Games and Howell 1976) . As with the Tukey's test associated with the ANOVA test, the results of the Games-Howell Test indicated which psychological item means were statistically different across the four mode choices. On the other hand, if the Welch ANOVA test resulted in failing to reject the null hypothesis that the variances were the same, no post hoc test was needed.

A summary of the process followed to determine which ANOVA related statistical tests to perform is provided in Figure 16.

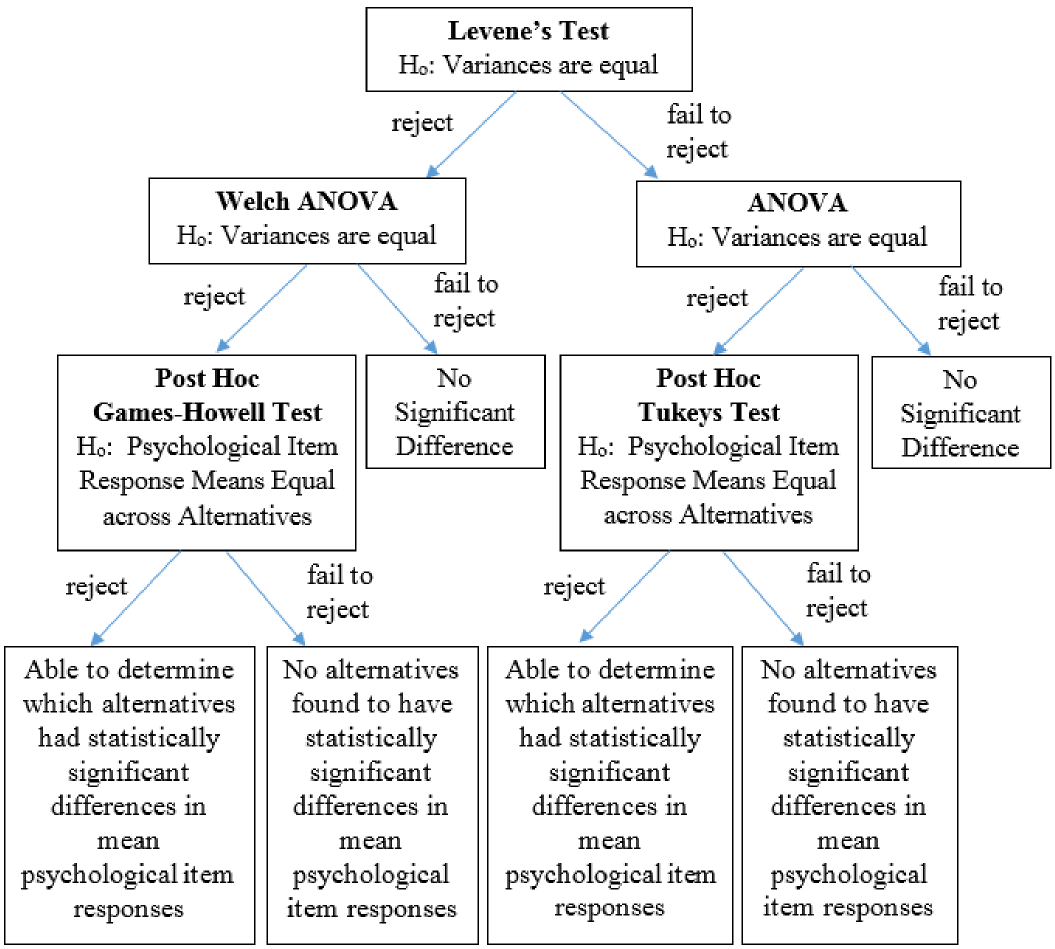


Figure 16. Flowchart used to determine appropriate ANOVA related statistical tests in checking for differences in mean psychological item response across alternatives.

6.3.2 Kruskal-Wallis Test Procedures (to compare mean ranks for psychological items by mode)

In addition to the parametric ANOVA test procedure, a non-parametric Kruskal-Wallis H Test (Devore 2008) was also performed with SPSS. In the present study, the main reason for performing multiple exploratory tests (i.e., ANOVA test procedures, Kruskal-Wallis test procedures, and the Ordinal Regression Models (with logit links)) to compare the psychological item responses across modes was to enable comparison across the results obtained from each type of test. All three of the test procedures were hypothesized to produce similar results, which was largely the case.

Given the exploratory nature of the Kruskal-Wallis H test, as with the ANOVA test procedures, whether the assumptions were met did not dictate whether the test was carried out, as the statistical analyses were exploratory in nature. As with the ANOVA test, the Kruskal-Wallis H Test is omnibus, requiring post hoc tests to determine which modes have statistically significant different responses for a given psychological item.

For the present study, although the distribution shapes may be similar for some psychological items across mode, to be conservative, the mean rank was considered (which can still be done if the distribution shapes for the different dependent variable groups are different). This was done by performing a Kruskal-Wallis one-way ANOVA (k samples) test to compare distribution across groups. Essentially, when the mean ranks are considered, the responses to the dependent variable (the psychological items in the present study) are assigned a value associated with their rank (smallest response assigned a value of 1, next smallest assigned a value of 2, etc.) for a given independent variable

(DA-GPL, CP-GPL, DA-EL, or CP-EL in the present study). If there are multiple SP question responses with the same Likert scale response, or in other words, “ties” in rank (which was clearly the case given the 9-point Likert scale and the thousands of SP question responses obtained), all of the values associated with a given response are assigned the average rank value. As an example, if four responses were associated with the Likert scale value of 1 (the lowest possible Likert scale response), all four responses would be assigned the corresponding “mean rank” value of (1+2+3+4)/4=2.5, rather than all being assigned a rank value of 1 (Hecke 2012). The mean rank obtained for all of the responses can then be compared by mode by performing a pairwise comparison (i.e., Mann-Whitney test for each pair of modes), using a Bonferroni correction (ResearchGate 2013). Based on the sign of the test statistic (i.e., whether it is positive or negative), it is possible to compare the mean ranks of the distributions in terms of which one has a higher mean rank value (Laerd Statistics 2015a).

6.3.3 Ordinal Regression Models (Logit Link) (to compare log odd ratios of modes)

In addition to the ANOVA test procedures and the Kruskal-Wallis test procedures, an ordinal regression analysis (with a logit link) was performed in SPSS (Laerd Statistics 2015c). Ultimately, this allowed the log odds ratios to be calculated, which allowed for a statistical comparison of the mean responses to the psychological items for the various modes. This type of analysis rests on the proportional odds assumption. Again, given the exploratory nature of the statistical analyses, whether all of the assumptions associated with the test were met was not viewed as critical. See Section 6.2 of Agresti (2007) for further discussion on cumulative odds ordinal regression with proportional odds, or what he terms the “cumulative logit models with proportional odds property”. Note that the respondents’ answers to the psychological item using a 9-point Likert scale was the response. A Wald test statistic is used in determining significance.

The following explanation may be helpful in understanding how the log odds ratios can be interpreted. Assume the reference mode log odds to be 1.0, and the 95th percentile significance range of the log odds for a second mode (for a given psychological item) to be 1.2 to 1.4. Thus, it could be said that the odds of the mean response for the second mode being one whole, Likert scale step higher (i.e., 2 instead of 1, 8 instead of 7, etc.) is 1.2 to 1.4 times the odds of the mean response for the reference mode being one whole step higher. The CP-EL mode was arbitrarily assigned to be the reference mode for the analysis. If the 95th percentile log odds ratio contained “1.00”, the mean psychological item response for that mode was not statistically different from that of the reference mode. However if the 95 percentile log odds ratio was greater (lower) than 1.00 in its entirety, the mean psychological item response for the mode was statistically higher (lower) than the mean of the reference mode.

Comparisons not involving the reference mode were also possible. If the 95th percentile log odds ratios overlapped for two modes, the difference in mean psychological item response for those two modes was not statistically significant. In this manner, pairwise comparisons were made across various modes for the psychological items. Again, the results obtained from this exploratory procedure were similar to those obtained from the ANOVA test procedures and the Kruskal-Wallis test procedures.

A summary of the pairwise comparisons obtained from the ANOVA test procedures, the Kruskal-Wallis test procedures, and the ordinal regression analysis (logit link) is provided in Table 12. Note that for the ANOVA test procedures and the Ordinal Regression (with logit link) results, the mode with the higher average psychological item response score is said to be “greater”. For the Kruskal-Wallis test procedures, the mode with the higher mean rank is said to be “greater”.

Table 12. Statistically Significant Pairwise Comparisons (at a 0.05 significance level) Obtained from Exploratory Statistical Test Results

	Exploratory Statistical Test Results		
Psychological Item	**One-Way ANOVA Test Procedures**	**Kruskal-Wallis Test Procedures**	**Ordinal Regression (with logit link)**
PSY1: It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time.	DA-GPL>DA-EL, CP-GPL>DA-EL, DA-EL<CP-EL	DA-GPL>DA-EL, CP-GPL>DA-EL, DA-EL<CP-EL	DA-GPL>DA-EL, CP-GPL>DA-EL, DA-EL<CP-EL, CP-GPL>CP-EL[A]
PSY2: Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.	DA-GPL<DA-EL, DA-GPL<CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL<DA-EL, DA-GPL<CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL<DA-EL, DA-GPL<CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL, CP-GPL<CP-EL
PSY3: If I were listening to the radio and heard there is a major crash on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.	None	None	None
PSY4: When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	DA-GPL<DA-EL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL, DA-GPL>CP-GPL[A]	DA-GPL<DA-EL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL, DA-GPL>CP-GPL[A]	DA-GPL<DA-EL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL
PSY5: I have often found that what is going to happen will happen.	None	None	None

Table 12. continued

Psychological Item	Exploratory Statistical Test Results		
	One-Way ANOVA Test Procedures	**Kruskal-Wallis Test Procedures**	**Ordinal Regression (with logit link)**
PSY6: I usually choose to use the express lane only at the last second, after observing freeway traffic for as long as possible.	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL DA-EL<CP-EL	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL
PSY7: Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	DA-GPL>CP-GPL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL>CP-GPL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL>CP-GPL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL
PSY8: Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	None	None	None
PSY9: I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.	DA-GPL>DA-EL, CP-GPL>DA-EL, DA-EL<CP-EL	DA-GPL>DA-EL, CP-GPL>DA-EL, DA-EL<CP-EL	DA-GPL>DA-EL, CP-GPL>DA-EL, DA-EL<CP-EL, DA-GPL>CP-EL[A]
PSY10: I only choose to use the express lanes if the general purpose lanes seem crowded.	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL DA-EL<CP-EL	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL
PSY11: I rarely complain about traffic problems because that will not help fix the problem.	DA-GPL<CP-GPL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL	DA-GPL<CP-GPL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL	DA-GPL<CP-GPL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL
PSY12: The coordination involved with carpooling is more hassle than it is worth.	DA-GPL>CP-GPL, DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL, CP-GPL>CP-EL[A]	DA-GPL>CP-GPL, DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL, CP-GPL>CP-EL[A]	DA-GPL>CP-EL, DA-GPL>CP-GPL, CP-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL
PSY13: Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	DA-GPL>CP-EL	DA-GPL>CP-EL, DA-EL>CP-EL[A]	DA-GPL>CP-EL, DA-EL>CP-EL[A]
PSY14: I often look up information about traffic conditions prior to driving anywhere.	None	None	DA-GPL<CP-EL[A]
PSY15: The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	None	None	None

Table 12. continued

	Exploratory Statistical Test Results		
Psychological Item	**One-Way ANOVA Test Procedures**	**Kruskal-Wallis Test Procedures**	**Ordinal Regression (with logit link)**
PSY16: I tend to make choices about which road to use based on the traffic I encounter.	DA-GPL>DA-EL	DA-GPL>DA-EL	DA-GPL>CP-EL
PSY17: I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	DA-EL<CP-EL[A]	None	DA-EL<CP-EL[A]
PSY18: I listen to the radio while driving so I can get updates on traffic.	DA-GPL<CP-GPL, DA-GPL<CP-EL, CP-GPL>DA-EL, DA-EL<CP-EL	DA-GPL<CP-GPL, DA-GPL<CP-EL, CP-GPL>DA-EL, DA-EL<CP-EL	DA-GPL<CP-GPL, DA-GPL<CP-EL, CP-GPL>DA-EL, DA-EL<CP-EL, CP-GPL>CP-EL[A]
PSY19: I do not like relying on others for rides.	DA-GPL>CP-GPL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL>CP-GPL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL>CP-GPL, DA-GPL>CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL
PSY20: I generally choose to use the express lane only when I feel it is the only way I will make it to my destination on time.	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL	DA-GPL>DA-EL, DA-GPL>CP-EL, CP-GPL>DA-EL, CP-GPL>CP-EL, DA-EL<CP-EL
PSY21: I would choose to use the express lane, knowing there is a 50 percent chance it will not save me time.	DA-GPL<DA-EL, DA-GPL<CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL<DA-EL, DA-GPL<CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL	DA-GPL<DA-EL, DA-GPL<CP-EL, CP-GPL<DA-EL, DA-EL>CP-EL
PSY22: I would invest 10% of my annual income in a quality/blue-chip stock.	None	None	None
PSY23: I would lend a friend the money needed to purchase a $45 toll tag so they could use the EL.	DA-GPL<DA-EL, DA-GPL<CP-EL	DA-GPL<DA-EL, DA-GPL<CP-EL	DA-GPL<DA-EL, DA-GPL<CP-EL, DA-EL>CP-EL[A]
PSY24: I would lend a friend an amount of money equivalent to one month's income.	DA-GPL<DA-EL[A]	DA-GPL<DA-EL[A]	None
PSY25: I would bet a day's income at the horse races.	DA-EL>CP-EL, DA-GPL<DA-EL [A]	DA-EL>CP-EL, DA-GPL<DA-EL[A]	DA-EL>CP-EL

[A] Indicates that this pairwise comparison was only found to be statistically significant at the 0.05 significance level for one or two of the tests (i.e., not for all three tests).

As shown in Table 12, there were many psychological items that had different mean values (or mean rank values) based on the mode selected by the respondents. Note that psychological items not found to have significant differences between ML modes in these three exploratory statistical tests are unlikely to be useful in modeling ML setting decisions (i.e., lane choice and/or carpooling decisions).

6.3.4 Correlations

Next, bivariate correlations were calculated for the psychological items and some key trip and demographic variables (Devore 2008). Spearman's rank correlations were calculated for the psychological items, which are a nonparametric counterpart of the Pearson correlations (Laerd Statistics 2015d) and are appropriate for Likert scale data. Given the large sample size, many psychological items appeared to be correlated based simply on significance level. However, the higher the correlation coefficient, the more highly correlated the two variables were. Any variables with a correlation coefficient value greater than an absolute value of 0.2 were flagged for potential collinearity. This resulted in the psychological items shown in Table 13 being flagged for correlation with respect to one another. A cutoff value of 0.2 may be lower than what is typically used. However, note that none of the correlations investigated were that large (i.e., very close to -1.0 or 1.0), so use of this cutoff value was still somewhat informative.

Table 13. Psychological Items Flagged for Correlation

Psychological Item Number	Description	Other Psychological Items Correlated With
PSY1	It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time.	2, 6, 8, 9, 10, 20
PSY2	Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.	1, 6, 9, 10, 20, 21
PSY3	If I were listening to the radio and heard there is a major crash on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.	none
PSY4	When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	5
PSY5	I have often found that what is going to happen will happen.	4, 8
PSY6	I usually choose to use the express lane only at the last second, after observing freeway traffic for as long as possible.	1, 2, 9, 10, 20, 21
PSY7	Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	12,19
PSY8	Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	1,5,9,13
PSY9	I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.	1, 2, 6, 8, 10, 20
PSY10	I only choose to use the express lanes if the general purpose lanes seem crowded.	1, 2, 6, 9, 20, 21
PSY11	I rarely complain about traffic problems because that will not help fix the problem.	none

Table 13. continued

Psychological Item Number	Description	Other Psychological Items Correlated With
PSY12	The coordination involved with carpooling is more hassle than it is worth.	7, 19
PSY13	Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	8
PSY14	I often look up information about traffic conditions prior to driving anywhere.	15, 16, 18
PSY15	The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	14, 16, 18
PSY16	I tend to make choices about which road to use based on the traffic I encounter.	14, 15, 17
PSY17	I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	16
PSY18	I listen to the radio while driving so I can get updates on traffic.	14, 15
PSY19	I do not like relying on others for rides.	7, 12
PSY20	I generally choose to use the express lane only when I feel it is the only way I will make it to my destination on time.	1, 2, 6, 9, 10
PSY21	I would choose to use the express lane, knowing there is a 50 percent chance it will not save me time.	2, 6, 10
PSY22	I would invest 10% of my annual income in a quality/blue-chip stock.	23, 24
PSY23	I would lend a friend the money needed to purchase a $45 toll tag so they could use the EL.	22, 24
PSY24	I would lend a friend an amount of money equivalent to one month's income.	22, 23, 25
PSY25	I would bet a day's income at the horse races.	24

The correlations associated with trip and demographic characteristics thought to potentially be of interest in modeling were also calculated. Both the Spearman's rank correlations and Pearson correlations were considered. Only those variables of interest that were numeric or ordinal were considered. Prior to performing the analysis, respondents who indicated that it was easier to tell their hourly wage than their household income (i.e., household income (HHINC) equals 10) were removed so that the results were not biased by irrelevant data. A summary of those trip and demographic variable results based on the Pearson and Spearman rank correlation coefficients is provided in Table 14. Those variable pairs associated with a correlation coefficient absolute value greater than 0.2 for a given correlation coefficient type are listed in the appropriate column, while those variables not found to be highly correlated with another considered variable (i.e., that were not associated with any correlation coefficients with an absolute value greater than 0.2), are listed with the word "none" in the respective correlation column.

Table 14. Trip and Demographic Variable Results Based on Pearson or Spearman's Rank Correlation Coefficients

Trip or Demographic Variable	Other Trip and Demographic Variables Correlated with using Pearson	Other Trip and Demographic Variables Correlated with using Spearman's Rank
LENGTH	none	none
VEHOCC	none	none
NUMWWTRP	none	none
AGE	CHILDAGE	CHILDAGE, HHSIZE
GENDER	none	none
CHILDAGE	AGE, HHSIZE	AGE, HHSIZE
EDUC	HHINC	HHINC
HHINC	EDUC	EDUC, HHNUMVEH
HHSIZE	CHILDAGE	AGE, CHILDAGE, HHNUMVEH
HHNUMVEH	none	HHINC, HHSIZE

- LENGTH=Trip Length; VEHOCC=Vehicle Occupancy; NUMWWTRP=Number of Workweek Trips; AGE=Age; GENDER=Gender; CHILDAGE=Child Age; EDUC=Education Level; HHINC=Household Income Level; HHSIZE=Household Size; HHNUMVEH=Household Number of Vehicles

The following correlations between the following variables were of particular interest:

- CHILDAGE and AGE
- EDUC and HHINC
- CHILDAGE and HHSIZE
- AGE and HHSIZE
- HHINC and HHNUMVEH
- HHSIZE and HHNUMVEH

These correlations were considered in some of the various approaches taken in the creation of trip and demographic models, as discussed in greater detail in the following section.

6.4 Mixed Logit Models

The summaries, crosstabs, and statistical analyses discussed in Sections 6.1-6.3 provided an overview of the data, and aided in forming hypotheses about which variables (trip and demographic variables, as well as psychological items) seemed most promising in helping to predict lane choice and/or carpooling decisions in ML settings.

Prior to modeling in NLOGIT (Greene (c) 1986-2012), the responses were properly formatted. This resulted in 12 lines of data for each respondent (three SP questions, with four mode options each). With the responses from 4,712 respondents being deemed useable for our modeling purposes, this resulted in 56,544 rows of data.

A systematic procedure was followed in developing MMNL models. Three basic types of models were initially constructed—each with a different focus:

- Trip and Demographic Characteristics
- Psychological Items
- Psychological Scales

Based on the findings of each of these categories of models, subsequent models were made that combined variables of interest from multiple categories. The details surrounding the model creation process are provided in this section—with further discussion and detail given for those models that were found to perform well.

6.4.1 Criteria Used to Evaluate Models

The three main criteria considered to gauge how well the models performed included VTTS, adjusted rho squared value, and percent correctly predicted values (overall and for the CP-EL alternative). The first method to calculate VTTS was used in assessing all of the models discussed within the present research effort, and is shown below in Equation (8).

$$VTTS = 60 * \frac{c\_time}{c\_toll} \tag{8}$$

where

c_time=travel time coefficient

c_toll=toll coefficient

The second method of calculating VTTS was only employed for the five combined models (Models 8a-12a), and is further discussed in Section 6.5. This second method accounts for potential differences in VTTS across household income level; thereby accounting for the hypothesized higher VTTS for households with a higher household income. This method results in the same number of VTTS estimates as there are household income groups being considered. The calculation is shown in Equation (9).

$$VTTS = 60 * \frac{c\_time}{c\_toll} * Ln(MEDINC) \tag{9}$$

where

$MEDINC$=median income range in the household income category

c_time=travel time coefficient

c_toll=toll coefficient

Various methods of calculating the adjusted rho squared value exist. Within the present study, the adjusted rho squared value with respect to the zero model was used. The equation used to calculate the adjusted rho squared value with respect to the zero model (which is equivalent to their being an equal likelihood of choosing each alternative) is shown in Equation (10) (Koppelman and Bhat 2006, p. 81).

$$\bar{\rho}_0^2 = 1 - \frac{LL(\hat{\beta}) - K}{LL(0)} \tag{10}$$

where

$\bar{\rho}_0^2$=adjusted rho squared value with respect to the zero model;

$LL(\hat{\beta})$=the log-likelihood of the estimated model;

$LL(0)$=the log-likelihood with zero coefficients; and

K=the number of parameters in the estimated model

The percent correctly predicted value is simply the percentage of time the mode selected by the respondent matched the mode with the highest utility in the model. Further analysis can be performed to determine the percent correctly predicted value for a given mode, which may provide insight into models that are able to effectively predict modes that are used less and therefore more difficult to predict. Thus, the models discussed within the present research study include a reference to the percent correctly predicted value for the CP-EL alternative, in addition to the overall percent correctly predicted value. Some example code (corresponding to Model 8 described in Section 6.4.6) of the models created in NGLOGIT is provided in Appendix F.

6.4.2 Trip and Demographic Characteristic Models

Models containing trip and demographic characteristics were initially developed independent from those models made using psychological items and psychological scales. The first step in developing baseline trip and demographic characteristic models was to run models with just travel time, toll, ASCs, and the variables associated with a given trip or demographic variable. The proper filters were used to filter out data deemed unrealistic for household size (RHHSIZE), number of household vehicles (RHHVEH), and number of work week trips (RNUMWWTR) (defined previously in

Table 6).

Note that unlike the psychological items that were developed using a Likert scale, several of the trip and demographic characteristic variables had to be recoded to be useful in

NLOGIT. A list of the trip and demographic characteristics that were originally considered for inclusion in this category of models is provided in Table 15, along with a description of the recoded variables, where applicable.

Table 15. List of Trip and Demographic Variables Originally Considered for Inclusion in Models

Variable	Description of NLOGIT Recoding
TRPPURP-Trip Purpose	-
DAYWEEK-Day of the Week	WEEKDAY=Monday-Friday
LENGTH-Length of most recent trip on local EL corridor in question	SHORTTRP: 10 miles or less; MIDTRP=11-20 miles; LONGTRP=More than 20 miles
VEHOCC-Vehicle Occupancy	-
NUMWWTRP-Total number of workweek trips during past full work week (Monday-Friday) on the local EL corridor	-
AGE-Age	LOWAGE=16-34-years-old; MIDAGE=35-54-years-old; HIGHAGE=55+-years-old
GENDER-Gender	-
HHTYPE-Household Type	-
CHILDAGE-Is your child(ren) between 5 to 17 years old (school age)?	-
OCC-Occupational or work status	-
EDUC-Last year of school completed	LOWEDUC=Less than high school/High school graduate; MIDEDUC=Some college or vocational school/College Graduate; HIGHEDUC=Postgraduate degree
HHINC-Gross annual household income before taxes in 2013	LOWINC=Less than $25,000; LMIDINC=$25,000-$49,999; HMIDINC=$50,000-$99,999; HINC=$100,000 or more
HHSIZE-Household Size	-
HHNUMVEH-Number of motor vehicles available for use by members of household	-

Those trip and demographic variables found to be significant within these models were considered for inclusion in the next round of model creation. However, some of the trip and demographic characteristics that were significant in preliminary models were omitted from subsequent models in an attempt to reduce potential collinearity issues. Thus, the variables of HHNUMVEH, CHILDAGE, and AGE were not included in subsequent models, given their potential correlation issues discussed previously in Section 6.3.4.

Once a model where all of the included trip and demographic variables were statistically significant at the 0.01 significance level was obtained (with 500 pts and 500 max iterations), models adding back-in the three trip and demographic variables that were originally removed to help account for potential correlation issues (HHNUMVEH, CHILDAGE, and AGE) were added back into the model, for alternatives where they were significant in the initial models, to see if they were still significant. The items were tested by adding them back into the model both individually (one variable at a time) and simultaneously (all three variables at the same time). The result was that the model that re-included the AGE variable on alternatives where they were significant in the initial model, resulted in it not only being significant for some alternatives, but also improving both the overall and CP-EL percent correctly predicted values. The model that included all three re-introduced trip and demographic variable simultaneously (i.e., HHNUMVEH, CHILDAGE, and AGE) did not result in as good of a model as when just AGE was reintroduced. The model with the re-introduced AGE variable was further refined until all of the included trip and demographic variables were statistically significant at the 0.01 significance level. This resulted in the baseline trip and demographic model. As mentioned in the discussion on correlation provided in Section 6.3.4, AGE was found to be correlated with CHILDAGE and HHSIZE—neither of which are present in the baseline trip and demographic model.

At this point, an analysis of the impact of removing trip and demographic variables from the baseline model was performed to determine the recommended trip and demographic model. The reason for wanting to limit the number of items is slightly different for the models involving trip and demographic information, and those containing psychological items and scales (discussed further in Section 6.4.3.3). In terms of trip and demographic information, it can most likely be assumed that these items would be included in most EL setting surveys. Therefore, their inclusion in models will probably not make the survey itself any longer than is standard. However, if a very similar result in terms of adjusted rho squared value or percent correctly predicted value can be achieved by using a smaller number of variables, it is probably more desirable and recommendable.

During the reduction process, the p-value associated with a given variable in the baseline model was used as a guide in determining the order in which to remove variables. Somewhat surprisingly, the model with just travel time, toll, and VEHOCC in the CP-EL alternative produced a model not much worse than the baseline model in terms of the overall percent correctly predicted value; and an improved percent correctly predicted value for the CP-EL alternative. A comparison of the baseline model, the recommended model and a model with just travel time, toll, and ASCs is provided in Table 16.

Table 16. Trip and Demographic Models

Mode	Model 1: Basic Model with Just Travel Time, Toll, and ASCs (n=14,136)	Model 2: Baseline "Good" Trip and Demographic Model (n=14,040)	Model 3: Recommended Trip and Demographic Model (n=14,070)
DA-GPLs	-0.54xTT*** -0.84xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.85xToll***
CP-GPLs	-11.01*** -0.54xTT*** -0.84xToll***	-13.61*** -0.54xTT*** -0.85xToll*** +2.12xVEHOCC***	-10.45*** -0.54xTT*** -0.85xToll***
DA-ELs	-1.17*** -0.54xTT*** -0.84xToll***	-1.74*** -0.54xTT*** -0.85xToll*** +1.12xWEEKD*** -0.04xNUMWW*** -0.80xMALE*** +0.48xHINC***	-1.17*** -0.54xTT*** -0.85xToll***
CP-ELs	-9.53*** -0.54xTT*** -0.84xToll***	-14.87*** -0.54xTT*** -0.85xToll*** -4.52xVEHOCC*** +1.04xLOWAGE***	-14.82*** -0.54xTT*** -0.85xToll*** +4.64xVEHOCC***
Information Related to Model Fit			
VTTS ($/hr)	38.78	37.99	38.56
K (DOF)	9	16	10
$\boldsymbol{\rho^2}$	0.431	0.445	0.441
$\boldsymbol{\rho^2_{adjusted}}$	0.430	0.445	0.441
% Cor. Pred. Overall	53.87	55.13	54.78
% Cor. Pred. For CP-EL	0.00	12.15	12.28

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level
- TT=Travel Time; VEHOCC=Vehicle Occupancy; WEEKD=Weekday (Monday-Friday); NUMWW=Number of workweek trips; MALE=Male; HINC=High Household Income (Household Income $100,000 or more); LOWAGE=Low Age (16-34-years-old)

There is naturally a close link between the vehicle occupancy for a respondent's most recent trip along the local EL corridor in question (VEHOCC), and the EL setting alternative selected in the SP questions. However, just because the respondent either did or did not carpool during their most recent trip on the local EL in question does not mean that they will select an associated mode in the SP questions. Thus, rather than choose to eliminate this variable from modeling, it was determined to leave it in the models in question because, as with vehicle occupancy, some of the psychological items and psychological scales also have close ties to carpooling.

6.4.3 Psychological Item Models

Within this subsection, the methodology followed in creating psychological item models is described. Those psychological items found to be of special interest in better understanding decisions made in EL settings (i.e., lane choice and/or carpooling decisions) are described.

6.4.3.1 Clustering, then Combining, then Eliminating Insignificant Variables

The first approach taken in creating MMNL models with psychological items was to run five different models. Each of the models contained clusters of five of the 25 psychological items, placed on three of the four (CP-GPL, DA-EL, CP-EL) mode choice alternatives. The DA-GPL alternative was the reference mode. The first model contained psychological items 1-5, the second model contained psychological items 6-10, etc. Travel time and toll were present for all four mode alternatives (though the toll was zero for most mode alternatives), along with an ASC for the CP-GPL, DA-EL, and CP-EL mode options. The models were run with 20 points (related to Halton draws) and 20 maximum iterations. Those psychological items that were significant for a given mode were retained for inclusion in future models.

While initial exploratory models were run with 20 points and 20 maximum iterations, some subsequent models, and all final evaluations of whether the models were "good" were performed using models obtained with 500 points and 500 maximum iterations. However, in each case, the number of iterations performed before an adequate solution was obtained was always well below 500 iterations.

6.4.3.2 Accounting for Correlation

At this point, the potential effects of correlation between the psychological items were considered. When variables that are highly correlated are in a model, it may mask the importance of each variable due to multicollinearity (Agresti 2007). Thus, a few different approaches were taken to see if accounting for correlation, and the issue of multicollinearity, could lead to an improved model, with correlation being accounted for in different steps of the model making process.

Ultimately, after efforts to address multicollinearity issues, there were five "good" models produced, each of which resulted in comparable adjusted rho squared values and percent correctly predicted values. From among these "good" models, the model with the fewest number of variables was selected to be the starting point for the next phase of the psychological item model creation process.

6.4.3.3 Reducing the Number of Variables in the Model

To this point, the goal was to produce the best model (based on the criteria of VTTS, adjusted rho squared value, and percent correctly predicted values) using the psychological items. However, at this point, the goal shifted to identifying which psychological items were most critical for better modeling travel behavior in ML settings (i.e., lane choice and/or carpooling decisions). In other words, the inclusion of additional psychological items in the models may indeed contribute to a higher percent correctly predicted value, with relatively minimal adverse effect on the adjusted rho squared value. However, the ultimate goal was to determine at what point including additional psychological variables in the model provided only minimal improvements; thereby guiding the process of determining which psychological items to potentially include in future ML surveys, given the desire to keep the length of surveys to a minimum.

With this goal in mind, models in some sort of reduced form of the baseline "good" model were created. Generally, one variable associated with a given alternative in the model was removed at a time. Decisions on the order to remove psychological item variables were guided by the p-values associated with the NLOGIT output from a previous model. Variables with high p-values were suspect to be removed from subsequent models. Some models were run simultaneously; therefore, the decision of which variable to remove was not necessarily made based on the p-value associated with the most recent model created. This type of clustering approach was used to speed-up the model making process. The number of models run simultaneously varied.

As the reduction of the original "good" model occurred, the percent correctly predicted value generally trended downward (though there were some slight spikes in the percent correctly predicted value when additional variables were removed). Models continued to be reduced until no psychological items remained in the model—leaving only travel time, toll, and ASCs in the model.

Ultimately, determining which model is able to use the fewest number of psychological items while still achieving a “good” model required engineering judgment. There were three or four models that seemed to be around the desired cutoff point. The psychological items included in each of these models were considered in making the final decision about which model to consider ideal, given the goal. Using this process, the model containing the following psychological items was selected:

- **Psychological Item #2 (not part of one of the four scales in question):** Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.
- **Psychological Item #4 (not part of one of the four scales in question):** When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.
- **Psychological Item #9 (part of scale associated with the Tendency to Take Risks construct):** I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.
- **Psychological Item #10 (not part of one of the four scales in question):** I only choose to use the express lane if the general purpose lanes seem crowded.
- **Psychological Item #12 (part of scale associated with the Reliance on Others construct):** The coordination involved with carpooling is more hassle than it is worth.

- **Psychological Item #19 (part of scale associated with the Reliance on Others construct):** I do not like relying on others for rides.

Recall that the reason for reducing the baseline "good" model was to limit the number of psychological items recommended for inclusion in a future survey related to travel behavior on MLs. Thus, it was determined that including a psychological item on multiple alternatives (i.e., using it as more than one variable in the model) would not require any additional psychological items being asked. Therefore, at this point, these six psychological items were each added back into the model as additional variables for other alternatives for which they were significant in the baseline model, to see if it would improve the more reduced model that contained the same six psychological items. Using this approach, the final recommended model containing psychological items is described in Table 17. The baseline "good" model and the model containing just travel time, toll, and ASCs are also shown to facilitate comparison.

Table 17. Psychological Item Models

Mode	Model 4: Baseline "Good" Psychological Item Model (n=13,704)	Model 5: Recommended Psychological Item Model (n=13,881)	Model 1: Basic Model with Just Travel Time, Toll, and ASCs (n=14,136)
DA-GPLs	-0.54xTT*** -0.80xToll***	-0.54xTT*** -0.82xToll***	-0.54xTT*** -0.84xToll***
CP-GPLs	-9.56*** -0.54xTT*** -0.80xToll*** +0.31xPSY11*** -0.31xPSY12*** +0.34xPSY18*** -0.48xPSY19***	-6.88*** -0.54xTT*** -0.82xToll*** -0.34xPSY12*** -0.37xPSY19***	-11.01*** -0.54xTT*** -0.84xToll***

Table 17. continued

Mode	Model 4: Baseline "Good" Psychological Item Model (n=13,704)	Model 5: Recommended Psychological Item Model (n=13,881)	Model 1: Basic Model with Just Travel Time, Toll, and ASCs (n=14,136)
DA-ELs	-1.12*** -0.54xTT*** -0.80xToll*** -0.12xPSY1*** +0.22xPSY2*** +0.10xPSY4*** -0.10xPSY6*** +0.14xPSY8*** -0.18xPSY9*** -0.17xPSY10*** -0.14xPSY20*** +0.12xPSY21*** +0.14xPSY25***	-0.98*** -0.54xTT*** -0.82xToll*** +0.30xPSY2*** +0.13xPSY4*** -0.23xPSY9*** -0.30xPSY10***	-1.17*** -0.54xTT*** -0.84xToll***
CP-ELs	1.35** -0.54xTT*** -0.80xToll*** -0.19xPSY4*** +0.25xPSY8*** +0.19xPSY9*** -1.07xPSY12*** -0.62xPSY19*** -0.21xPSY20*** +0.24xPSY21***	2.25*** -0.54xTT*** -0.82xToll*** -0.16xPSY4*** +0.17xPSY9** -1.11xPSY12*** -0.63xPSY19***	-9.53*** -0.54xTT*** -0.84xToll***
Information Related to Model Fit			
VTTS ($/hr)	40.61	39.38	38.78
K (DOF)	30	19	9
$\boldsymbol{\rho^2}$	0.474	0.470	0.431
$\boldsymbol{\rho^2_{adjusted}}$	0.473	0.469	0.430
% Cor. Pred. Overall	60.12	59.25	53.87
% Cor. Pred. For CP-EL	22.88	21.76	0.00

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level; **= Statistically significant at 0.05 significance level
- TT=Travel Time; PSY#=Psychological Item # _______ (Refer to Table 10 for description of psychological items)

As would be expected, the travel time and toll coefficients are negative. Those who indicated that "Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time" (psychological item #2) had a higher likelihood of selecting the DA-EL alternative than the DA-GPL alternative. This result is interesting, and hints at the idea that people who use the EL may do so looking ahead to the possibility that congestion could occur, even if at the time they choose to use the EL, congestion may or may not be present. Note that this item (psychological item #2) is not part of the four constructs of interest in this analysis. However, it supports the idea that some people who choose to drive alone in the express lane do so out of anticipation of potential congestion, in an effort to think ahead, and not necessarily because current conditions warrant the decision.

Those who indicated that "When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price" (psychological item #4) had a split response to ELs relative to the DA-GPL alternative. They had a higher likelihood of selecting the DA-EL alternative than the DA-GPL alternative. However, they had a lower likelihood of selecting the CP-EL alternative than the DA-GPL alternative. This result associated with higher agreement with psychological item #4 can be summarized below:

CP-EL < DA-GPL < DA-EL

Psychological item #4 appears to be double-barreled in nature—speaking to both convenience and price. Thus, if focused on the valuing convenience portion of the statement, it would make sense that those who value convenience would choose to bypass carpooling, given the extra time and hassle that is often associated with it. At the same time, respondents agreeing with psychological item #4 had a higher likelihood of selecting the DA-EL (tolled) alternative over the free DA-GPL alternative if they "do not pay much attention to price". "Not paying much attention to price" may be highly correlated with the sentiment that "my household income is fairly high, so I do not need to worry much about the cost of the EL". The results shown in Table 18 support this hypothesis. Note that the average response obtained for psychological item #4 is higher for respondents with a higher household income.

Table 18. Average Response to PSY4 with Respect to Household Income

	Household Income Less than $50,000	**Household Income $50,000-$99,999**	**Household Income Greater than $100,000**	**Total**
Average response to PSY4	3.69	4.01	4.69	4.40
Number of Respondents	378	1,390	2,754	4,522

In an effort to further investigate the logic behind those who value the convenience part of not carpooling having a higher likelihood of selecting the DA-GPL alternative than the CP-EL alternative, models relating to carpooling convenience (Model 5a and Model 5b) were created, as summarized in Table 19.

Table 19. Psychological Item Models-Considering Effect of Carpooling Convenience

Mode	Model 5: Recommended Psychological Item Model (n=13,881)	Model 5a: Psychological Item Model with PSY4, CPCONV, and PSY4xCPCONV (n=13,881)	Model 5b: Psychological Item Model with PSY4, CPINCON, and PSY4xCPINCON (n=13,881)
DA-GPLs	-0.54xTT*** -0.82xToll***	-0.54xTT*** -0.82xToll***	-0.54xTT*** -0.82xToll***
CP-GPLs	-6.88*** -0.54xTT*** -0.82xToll*** -0.34xPSY12*** -0.37xPSY19***	-6.88*** -0.54xTT*** -0.82xToll*** -0.30xPSY12*** -0.35xPSY19***	-6.53*** -0.54xTT*** -0.82xToll*** -0.36xPSY12*** -0.36xPSY19***
DA-ELs	-0.98*** -0.54xTT*** -0.82xToll*** +0.30xPSY2*** +0.13xPSY4*** -0.23xPSY9*** -0.30xPSY10***	-0.96*** -0.54xTT*** -0.82xToll*** +0.30xPSY2*** +0.13xPSY4*** -0.24xPSY9*** -0.30xPSY10***	-0.96*** -0.54xTT*** -0.82xToll*** +0.30xPSY2*** +0.13xPSY4*** -0.24xPSY9*** -0.30xPSY10***
CP-ELs	2.25*** -0.54xTT*** -0.82xToll*** -0.16xPSY4*** +0.17xPSY9** -1.11xPSY12*** -0.63xPSY19***	1.93*** -0.54xTT*** -0.82xToll*** -0.17xPSY4*** +4.85xCPCON*** +0.20xPSY4xCPCONV -1.02xPSY12*** -0.63xPSY19***	2.01*** -0.54xTT*** -0.82xToll*** -0.14xPSY4*** +5.56xCPINCON*** +0.07xPSY4xCPINCON -1.05xPSY12*** -0.61xPSY19***
VTTS ($/hr)	39.38	39.47	39.31
K (DOF)	19	20	20
$\boldsymbol{\rho^2}$	0.470	0.472	0.471
$\boldsymbol{\rho^2_{adjusted}}$	0.469	0.471	0.470
% Cor. Pred. Overall	59.25	59.73	59.44
% Cor. Pred. For CP-EL	21.76	24.46	23.11

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level ; **=Statistically significant at 0.05 significance level
- TT=Travel Time; PSY#=Psychological Item # _______ (Refer to Table 10 for description of psychological items); CPCONV=Carpooling Convenience Value; CPINCON=Carpooling Inconvenience Value

Model 5 (the recommended psychological item model) is included in the table as a point of reference. Two new variables (CPCONV and CPINCON), were created to enable further analysis on the impact that convenience of carpooling (for drivers) had on their PSY4 response. Note that the EXTRACP variable is only associated with drivers of carpools, and refers to how much extra time it took to pick up and drop off the passenger(s), in minutes.

- If VEHOCC>1 and EXTRACP=0 then CPCONV=1, otherwise CPCONV=0. Note that this group does not solely contain respondents who traveled exclusively with family members. It may also include neighbors or coworkers who shared a common origin or destination at the start or end of the trip.
- If VEHOCC>1, and EXTRACP is greater than or equal to 10 minutes and less than 120 minutes, then CPINCON=1, otherwise CPINCON=0.

As can be seen from the results obtained in Model 5a, for those drivers for whom carpooling was convenient (i.e., CPCONV=1), a higher level of agreeing with PSY4 was associated with a higher likelihood of selecting the CP-EL alternative than the DA-GPL alternative (beta value for PSYxCPCONV =+0.20). However, this result was not significant at a 90% significance level. In Model 5b, the interaction term associated with the CP-EL alternative (PSY4 x CPINCON), had a beta value that was small and positive (+0.07), and was not found to be significant at a 90% significance level. These results do not allow for any solid conclusions to be drawn with regards to convenience, PSY4 response, and whether respondents had a lower or higher likelihood of selecting the DA-GPL alternative over the CP-EL alternative—at least from the perspective of drivers who were part of a carpool during their most recent trip in the local EL corridor in question. Perhaps further investigation into the interaction effect associated with PSY4 and other variables (i.e., those who did not indicate that they carpooled during their most recent trip on the local EL corridor in question or those who did carpool but were a passenger rather than the driver) may provide further insight into why those with higher scores on PSY4 had a higher likelihood of selecting the DA-GPL alternative than the CP-EL alternative.

However, note that in Model 5a and Model 5b, respectively, the individual CPCONV and CPINCON beta values were *both* largely positive (+4.85 and +5.56 respectively). Thus, it appears that without regard to PSY4 response, those who indicated that they were the driver of a carpool for their most recent trip on the local EL corridor in question had a higher likelihood of selecting the CP-EL alternative than the DA-GPL alternative, regardless of whether or not they were "convenienced" (CPCONV=1) or "inconvenienced" (CPINCON=1) by carpooling during their most recent trip in the EL corridor. It would be expected drivers who were not inconvenienced by carpooling would probably have a higher likelihood of selecting the CP-EL alternative than the DA-GPL alternative; but the fact that even those persons who were "inconvenienced" by being the driver of a carpool still had a higher likelihood to carpool in the EL for free (CP-EL) than to drive alone in the GPL for free (DA-GPL) may point to some other benefit they feel they receive from carpooling—be it the time saved by using the EL, the social interaction, or a combination of these and other factors.

Those who agreed that they “cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time” (psychological item #9) had a lower likelihood of selecting the DA-EL alternative than the DA-GPL alternative. This result is not surprising. However, they had a higher likelihood of selecting the CP-EL alternative than the DA-GPL alternative. At first it may seem surprising that respondents agreeing with this statement would select an EL alternative. However, the fact that carpooling is free (with different definitions for the vehicle occupancy that constitutes carpooling being free for the various study areas), would cause the CP-EL alternative to not be directly tied to the statement as those selecting the DA-EL alternative. Also, note that the CP-EL variable associated with this psychological item (psychological item # 9) is only statistically significant at the 0.05 significance level, rather than the 0.01 significance level associated with the DA-EL alternative; though its inclusion in the model contributed to better model performance than had this variable been removed.

Those who indicated they agree with the statement “I only choose to use the express lane if the general purpose lanes seem crowded” (psychological item #10) had a lower likelihood of selecting the DA-EL alternative than the DA-GPL alternative. This result initially may seem to contrast the sentiment associated with the previously discussed finding that those who indicated that “Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time” (psychological item #2) had a higher likelihood of selecting the DA-EL alternative than the DA-GPL alternative. One of the main, yet subtle differences between these two items is the timeframe associated with the wording.

The statement “I only choose to use the express lane if the general purpose lanes seem crowded” (psychological item #10) is structured with regard to how *current* conditions seem. By contrast, the statement “Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time” (psychological item #2) speaks of thinking ahead to *future* conditions. Thus, it appears that those who feel that *future* conditions may make EL use advantageous tend to select the DA-EL alternative over the DA-GPL alternative. However, with regard to *current* conditions being crowded (or not) on the GPL, respondents had a higher likelihood of selecting the DA-GPL alternative than the DA-EL. Additionally, the association between current conditions and how respondents answered the SP questions is partially confounded by the fact that the “most recent trip” associated with the SP questions was associated with different levels of congestion for different respondents.

Those who feel that “The coordination involved with carpooling is more hassle than it is worth” (psychological item #12) had a lower likelihood of selecting the CP-GPL alternative than the DA-GPL alternative. Likewise, they had a lower likelihood of selecting the CP-EL alternative than the DA-GPL alternative. This result is not surprising. The same results were found for those who indicated that they “do not like relying on others for rides” (psychological item #19).

6.4.4 Psychological Scale Models

The first step in creating the psychological scale models was to create scale variables associated with each of the four constructs in question. This was done by summing the Likert scale results for the psychological items associated with each scale. The one exception to this was for psychological item #9, in the scale associated with the Tendency to Take Risks construct, which was reverse scored prior to adding it to the sum of the Likert scale values of the other psychological items in the scale. If there were blanks present for any one of the psychological items associated with the scale, the scale value was also left blank. A summary of the psychological items associated with each of the scales considered in this analysis is provided in Table 20.

Table 20. Summary of the Items Comprised in the Constructs and Associated Scales Considered in this Analysis

Construct Associated with Scale	Psychological Item Number	Psychological Item Description
Control of Situation and Destiny	1	It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time.
	5	I have often found that what is going to happen will happen.
	8	Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.
	13	Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.

Table 20. continued

Construct Associated with Scale	Psychological Item Number	Psychological Item Description
Tendency to Take Risks	9[R]	I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.
	21	I would choose to use the express lane, knowing there is a 50 percent chance it will not save me time.
	22	I would invest 10% of my annual income in a quality/blue-chip stock.
	23	I would lend a friend the money needed to purchase a $45 toll tag so they could use the express lane.
	24	I would lend a friend an amount of money equivalent to one month's income.
	25	I would bet a day's income at the horse races.
Reliance on Others (RO)	7	Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.
	12	The coordination involved with carpooling is more hassle than it is worth.
	19	I do not like relying on others for rides.
Analytical Tendency in Decision Making Process (AT)	14	I often look up information about traffic conditions prior to driving anywhere.
	15	The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.
	16	I tend to make choices about which road to use based on the traffic I encounter.
	18	I listen to the radio while driving so I can get updates on traffic.

[R] Indicates this item was reverse scored for the scale analyses.

Once each scale variable associated with a given construct was developed, the next step was to run initial models that contained variables for only one construct at a time. For these models, the variable was included within the CP-GPL, DA-ML, and CP-ML alternatives. In addition to the construct variables, travel time, toll, and ASCs were included in these initial models. These initial models were run with just 20 points and 20 maximum iterations. Those variables that were found to be significant in these initial models were then combined into one model and run with 500 points and 500 maximum iterations. The number of variables continued to be reduced, using the variable significance as a guide in determining which variables to remove.

The resulting model, where all included construct-related variables were statistically significant at the 0.01 significance level, included variables associated with all four constructs. These four scales were made-up of 17 psychological items. Therefore, recommending that all 17 psychological items be potentially included in future surveys was not practical, or overly helpful in determining exactly which constructs may be most helpful in better understanding travel behavior in EL settings (i.e., lane choices and/or carpooling decisions). Therefore, at this point, a similar reduction process to what was performed in the psychological item model making process was pursued. Engineering judgment was used in determining which model was ideal given the competing goals of trying to limit the number of constructs included in the model (thereby limiting the recommended length of potential future surveys) and trying to achieve a high adjusted rho squared value and percent correctly predicted values.

Through this process it was determined that including the scale associated with the Reliance on Others Construct (ROCON) for the CP-GPL and CP-EL alternatives resulted in the recommended model. Although the overall percent correctly predicted value decreased in comparison to the baseline model that contained all four of the scales related to the constructs in question, the percent correctly predicted value for the CP-EL alternative actually improved when only variables associated with the ROCON were included in the model. Including ROCON in all three alternatives (CP-GPL, DA-EL, CP-EL) slightly improved the overall percent correctly predicted value in comparison to when it was included for just the alternatives associated with carpooling. However, including the ROCON variable in the DA-EL alternative actually noticeably decreased the percent correctly predicted value associated with the CP-EL alternative. Therefore, the ROCON variable was not included in the DA-EL alternative for the recommended psychological scale model, which is summarized in Table 21, along with the baseline model and a model with just travel time, toll, and ASCs as points of reference.

Table 21. Psychological Scale Models

Mode	Model 6: Baseline "Good" Psychological Scale Model (n=13,476)	Model 7: Recommended Psychological Scale Model (n=13,878)	Model 1: Basic Model with Just Travel Time, Toll, and ASCs (n=14,136)
DA-GPLs	-0.53xTT*** -0.82xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.84xToll***
CP-GPLs	-6.82*** -0.53xTT*** -0.82xToll*** -0.24xROCON***	-7.23*** -0.54xTT*** -0.85xToll*** -0.26xROCON***	-11.01*** -0.54xTT*** -0.84xToll***
DA-ELs	-3.00*** -0.53xTT*** -0.82xToll*** -0.04xCSDCON*** +0.11xTRCON*** -0.03xATCON***	-1.15*** -0.54xTT*** -0.85xToll***	-1.17*** -0.54xTT*** -0.84xToll***
CP-ELs	2.22*** -0.53xTT*** -0.82xToll*** -0.59xROCON***	2.27*** -0.54xTT*** -0.85xToll*** -0.60xROCON***	-9.53*** -0.54xTT*** -0.84xToll***
Information Related to Model Fit			
VTTS ($/hr)	38.92	38.24	38.78
K (DOF)	14	11	9
$\boldsymbol{\rho^2}$	0.451	0.446	0.431
$\boldsymbol{\rho^2_{adjusted}}$	0.450	0.446	0.430
% Cor. Pred. Overall	55.60	54.81	53.87
% Cor. Pred. For CP-EL	18.32	18.87	0.00

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level
- TT=Travel Time; ROCON=Scale associated with the Reliance on Others Construct; CSDCON=Scale associated with the Control of Situation and Destiny Construct; TRCON=Scale associated with the Tendency to Take Risks Construct; ATCON=Scale associated with the Analytical Tendency in Decision Making Process Construct

6.4.5 Comparing the Different Types of Models

A side-by-side comparison of the adjusted rho squared values and overall and CP-EL alternative percent correctly predicted values obtained for the baseline and recommended models for each type of model (trip/demographic, psychological item, and psychological scale) is provided in Table 22.

Table 22. Side-by-Side Comparison of Models with One Variable Type

	Trip and Demographic Models	**Psychological Item Models**	**Psychological Scale Models**
Baseline			
$\boldsymbol{\rho^2}$	0.445	0.474	0.451
$\boldsymbol{\rho^2_{adjusted}}$	0.445	0.473	0.450
Overall Cor. Pred. (%)	55.13	60.12	55.60
CP-EL Alternative Cor. Pred. (%)	12.15	22.88	18.32
K (DOF)	16	30	14
Recommended			
$\boldsymbol{\rho^2}$	0.441	0.470	0.446
$\boldsymbol{\rho^2_{adjusted}}$	0.441	0.469	0.446
Overall Cor. Pred. (%)	54.78	59.25	54.81
CP-EL Alternative Cor. Pred. (%)	12.28	21.76	18.87
K (DOF)	10	19	11
Just Travel Time, Toll, and ASC			
$\boldsymbol{\rho^2}$	0.431	0.431	0.431
$\boldsymbol{\rho^2_{adjusted}}$	0.430	0.430	0.430
Overall Cor. Pred. (%)	53.87	53.87	53.87
CP-EL Alternative Cor. Pred. (%)	0.00	0.00	0.00
K (DOF)	9	9	9

- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- DOF=Degrees of Freedom

The models created using psychological items (both baseline and recommended) resulted in noticeably higher percent correctly predicted values (both overall and for the CP-EL alternative) than those obtained in either the trip and demographic models or the psychological scale models. They are even better than the psychological scale model that employs the use of all four scales in question (Scale associated with the Reliance on Others Construct (ROCON), Scale associated with the Control of Situation and Destiny Construct (CSDCON), Scale associated with the Tendency to Take Risks Construct (TRCON), and Scale associated with the Analytical Tendency in Decision Making Process Construct (ATCON)), which uses information from 17 psychological items.

6.4.6 Combining Models

Beyond the three initial types of models (trip and demographic models, psychological item models, and psychological scale models), additional combined models falling into one of the following two categories were created:

- Trip and Demographic + Psychological Items
- Trip and Demographic + Psychological Scales

These two types of combined models allowed for further comparisons to be made between psychological items and psychological scales, in terms of their usefulness in better understanding travel behavior in EL settings (i.e., lane choice and/or carpooling decisions).

As with the models created using just one of the three types of variables (trip and demographic, psychological items, or psychological scales), an effort was made in the model creation process to strike a good balance between creating a “good” model—in terms of the adjusted rho squared value and the percent correctly predicted values (both overall and for the generally harder to predict CP-EL alternative)—and in using discretion on the number of items included in the model.

Combined models containing trip and demographic variables and psychological item variables are summarized in Table 23. The baseline model in this case was taken as the "best" model (in terms of percent correctly predicted value) created through the process of beginning with the appropriate baseline or recommended models from the individual models and creating reduced models. The recommended models have fewer variables than the baseline model, but provide further insight into, more precisely, which variables are useful in modeling. Two recommended models—one with trip and demographic variables beyond just VEHOCC (Model 9) and one with VEHOCC as the only trip and demographic variable (Model 10)—were constructed.

Table 23. Combined Models for Trip and Demographic Items and Psychological Items

Mode	**Model 8: Baseline "Good" Trip and Demographic + Psychological Item Model (n=13,818)**	**Model 9: Recommended A Trip and Demographic + Psychological Item Model (n=13,818)**	**Model 10: Recommended B Trip and Demographic + Psychological Item Model (n=13,818)**	**Model 2: Baseline "Good" Trip and Demographic Model (n=14,040)**	**Model 3: Recommended Trip and Demographic Model (n=14,070)**	**Model 5: Recommended Psychological Item Model (n=13,881)**
DA-GPLs	-0.54xTT*** -0.82xToll***	-0.54xTT*** -0.82xToll***	-0.54xTT*** -0.81xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.82xToll***
CP-GPLs	-11.21*** -0.54xTT*** -0.82xToll*** +2.15x VEHOCC*** -0.43xPSY12***	-10.90*** -0.54xTT*** -0.82xToll*** +2.07x VEHOCC*** -0.42xPSY12***	-14.30*** -0.54xTT*** -0.81xToll*** +2.29x VEHOCC***	-13.61*** -0.54xTT*** -0.85xToll*** +2.12x VEHOCC***	-10.45*** -0.54xTT*** -0.85xToll***	-6.88*** -0.54xTT*** -0.82xToll*** -0.34xPSY12*** -0.37xPSY19***
DA-ELs	-0.79*** -0.54xTT*** -0.82xToll*** -0.43xMALE*** +0.30xPSY2*** +0.13xPSY4*** -0.24xPSY9*** -0.29xPSY10***	-0.84*** -0.54xTT*** -0.82xToll*** -0.43xMALE*** +0.30xPSY2*** +0.14xPSY4*** -0.24xPSY9*** -0.29xPSY10***	-1.04*** -0.54xTT*** -0.81xToll*** +0.30xPSY2*** +0.14xPSY4*** -0.25xPSY9*** -0.29xPSY10***	-1.74*** -0.54xTT*** -0.85xToll*** +1.12x WEEKD*** -0.04x NUMWW*** -0.80xMALE*** +0.48xHINC***	-1.17*** -0.54xTT*** -0.85xToll***	-0.98***- 0.54xTT*** -0.82xToll*** +0.30xPSY2*** +0.13xPSY4*** -0.23xPSY9*** -0.30xPSY10***

Table 23. continued

Mode	Model 8: Baseline "Good" Trip and Demographic + Psychological Item Model (n=13,818)	Model 9: Recommended A Trip and Demographic + Psychological Item Model (n=13,818)	Model 10: Recommended B Trip and Demographic + Psychological Item Model (n=13,818)	Model 2: Baseline "Good" Trip and Demographic Model (n=14,040)	Model 3: Recommended Trip and Demographic Model (n=14,070)	Model 5: Recommended Psychological Item Model (n=13,881)
CP-ELs	-3.24*** -0.54xTT*** -0.82xToll*** +3.54x VEHOCC*** +1.21x LOWAGE*** -0.16xPSY4*** -0.91xPSY12*** -0.54xPSY19***	-3.79*** -0.54xTT*** -0.82xToll*** +3.57x VEHOCC*** +1.13x LOWAGE*** -0.92xPSY12*** -0.56xPSY19***	-3.50*** -0.54xTT*** -0.81xToll*** +3.53x VEHOCC*** -0.93xPSY12*** -0.56xPSY19***	-14.87*** -0.54xTT*** -0.85xToll*** +4.52x VEHOCC*** +1.04x LOWAGE***	-14.82*** -0.54xTT*** -0.85xToll*** +4.64x VEHOCC***	2.25*** -0.54xTT*** -0.82xToll*** -0.16xPSY4*** +0.17x PSY9** -1.11x PSY12*** -0.63x PSY19***
Information Related to Model Fit						
VTTS ($/hr)	39.48	39.46	39.53	37.99	38.56	39.38
K (DOF)	21	20	17	16	10	19
ρ^2	0.479	0.478	0.477	0.445	0.441	0.470
$\rho^2_{adjusted}$	0.478	0.477	0.476	0.445	0.441	0.469
% Cor. Pred. Overall	60.70	60.64	60.58	55.13	54.78	59.25
% Cor. Pred. For CP-EL	30.02	30.02	29.16	12.15	12.28	21.76

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level
- TT=Travel Time; VEHOCC=Vehicle Occupancy; MALE=Male; LOWAGE=16-34-years-old; WEEKD=Weekday (Monday-Friday); NUMWW=Number of Workweek Trips; HINC=High Household Income (Household Income $100,000 or more); PSY#=Psychological Item # _______ (Refer to Table 10 for description of psychological items)

Not surprisingly, the baseline model for the combined trip and demographic and psychological items contains VEHOCC and many of the psychological items found in the recommended individual psychological item model. As would be expected, higher vehicle occupancy is associated with a higher likelihood of choosing one of the carpool options over the DA-GPL alternative. This baseline model also indicatives that males had a lower likelihood of selecting the DA-EL alternative than the DA-GPL alternative;

and that young travelers (LOWAGE) had a higher likelihood of selecting the CP-EL alternative than the DA-GPL alternative. Two recommended models are displayed in Table 23; one (Model 9) containing trip and demographic characteristics beyond just VEHOCC and the other (Model 10) with VEHOCC as the only trip and demographic variable. Note that the overall percent correctly predicted value is almost identical for Model 9 and Model 10. There is a small difference in the percent of travelers choosing CP-EL that were correctly predicted using Model 9 (30.02%) and Model 10 (29.16%).

The combined models containing trip and demographic variables and psychological scale variables are summarized in Table 24. The combined models that involved psychological items (Models 8-10) performed better than the combined models using psychological scales (Model 11 and Model 12) in terms of adjusted rho squared value and percent correctly predicted values (both overall and for the CP-EL alternative). An overview, which helps to highlight some of the main findings associated with the modeling performed as part of this research effort, is provided in Table 25.

Note that relative to the Basic Model with Just Travel Time, Toll, and ASCs (Model 1), the Baseline "Good" Trip and Demographic Model (Model 2) is associated with an improved adjusted rho squared value, percent correctly predicted value, and a large jump in the percent correctly predicted value for the CP-EL alternative. The Recommended Trip and Demographic Model (Model 3), which had vehicle occupancy as its only trip and demographic variable, resulted in a slightly lower percent correctly predicted valued compared to the Baseline "Good" Trip and Demographic Model (Model 2), and a slightly better percent correctly predicted value for the CP-EL alternative.

Table 24. Combined Models for Trip and Demographic Items and Psychological Scales

Mode	Model 11: Baseline "Good" Trip and Demographic + Psychological Scale Model (n=13,815)	Model 12: Recommended Trip and Demographic + Psychological Scale Model (n=13,815)	Model 2: Baseline "Good" Trip and Demographic Model (n=14,040)	Model 3: Recommended Trip and Demographic Model (n=14,070)	Model 7: Recommended Psychological Scale Model (n=13,878)
DA-GPLs	-0.54xTT*** -0.84xToll***	-0.54xTT*** -0.84xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.85xToll***
CP-GPLs	-13.23*** -0.54xTT*** -0.84xToll*** +2.16xVEHOCC***	-13.24*** -0.54xTT*** -0.84xToll*** +2.16xVEHOCC***	-13.61*** -0.54xTT*** -0.85xToll*** +2.12xVEHOCC***	-10.45*** -0.54xTT*** -0.85xToll***	-7.23*** -0.54xTT*** -0.85xToll*** -0.26xROCON***
DA-ELs	-0.72*** -0.54xTT*** -0.84xToll*** -0.73xMALE***	-1.14*** -0.54xTT*** -0.84xToll***	-1.74*** -0.54xTT*** -0.85xToll*** +1.12xWEEKD*** -0.04xNUMWW*** -0.80xMALE*** +0.48xHINC***	-1.17*** -0.54xTT*** -0.85xToll***	-1.15*** -0.54xTT*** -0.85xToll***
CP-ELs	-3.37*** -0.54xTT*** -0.84xToll*** +3.47xVEHOCC*** -0.50xROCON***	-3.37*** -0.54xTT*** -0.84xToll*** +3.45xVEHOCC*** -0.50xROCON***	-14.87*** -0.54xTT*** -0.85xToll*** +4.52xVEHOCC*** +1.04xLOWAGE***	-14.82*** -0.54xTT*** -0.85xToll*** +4.64x VEHOCC***	2.27*** -0.54xTT*** -0.85xToll*** -0.60xROCON***
Information Related to Model Fit					
VTTS ($/hr)	38.03	38.12	37.99	38.56	38.24
K (DOF)	13	12	16	10	11
ρ^2	0.456	0.455	0.445	0.441	0.446
$\rho^2_{adjusted}$	0.455	0.454	0.445	0.441	0.446
% Cor. Pred. Overall	56.67	56.38	55.13	54.78	54.81
% Cor. Pred. For CP-EL	28.29	28.61	12.15	12.28	18.87

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level
- TT=Travel Time; VEHOCC=Vehicle Occupancy; MALE=Male; ROCON=Scale associated with Reliance on Others Construct; WEEKD=Weekday (Monday-Friday); NUMWW=Number of Workweek Trips; HINC=High Income Household (household income $100,000 or more); LOWAGE=16-34-years-old

Table 25. Key Models Associated with Research Findings

Mode	Model 1: Basic Model with Just Travel Time, Toll, and ASCs (n=14,136)	Model 2: Baseline "Good" Trip and Demographic Model (n=14,040)	Model 3: Recommended Trip and Demographic Model (n=14,070)	Model 10: Recommended B Trip and Demographic + Psychological Item Model (n=13,818)	Model 12: Recommended Trip and Demographic + Psychological Scale Model (n=13,815)	Model 13: Just Six Psychological Item Variables Model (n=13,881)
DA-GPLs	-0.54xTT*** -0.84xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.85xToll***	-0.54xTT*** -0.81xToll***	-0.54xTT*** -0.84xToll***	-
CP-GPLs	-11.01*** -0.54xTT*** -0.84xToll***	-13.61*** -0.54xTT*** -0.85xToll*** +2.12x VEHOCC***	-10.45*** -0.54xTT*** -0.85xToll***	-14.30*** -0.54xTT*** -0.81xToll*** +2.29x VEHOCC***	-13.24*** -0.54xTT*** -0.84xToll*** +2.16x VEHOCC***	-6.18*** -0.32xPSY12*** -0.29xPSY19***
DA-ELs	-1.17*** -0.54xTT*** -0.84xToll***	-1.74*** -0.54xTT*** +1.12x WEEKD*** -0.04x NUMWW*** -0.80x MALE*** +0.48x HINC***	-1.17*** -0.54xTT*** -0.85xToll***	-1.04*** -0.54xTT*** -0.81xToll*** +0.30xPSY2*** +0.14xPSY4*** -0.25xPSY9*** -0.29xPSY10***	-1.14*** -0.54xTT*** -0.84xToll***	-0.33*** +0.14xPSY2 +0.06xPSY4*** -0.13xPSY9*** -0.15xPSY10***
CP-ELs	-9.53*** -0.54xTT*** -0.84xToll***	-14.87*** -0.54xTT*** -0.85xToll*** +4.52x VEHOCC*** +1.04x LOWAGE***	-14.82*** -0.54xTT*** -0.85xToll*** +4.64x VEHOCC***	-3.50*** -0.54xTT*** -0.81xToll*** +3.53x VEHOCC*** -0.93x PSY12*** -0.56x PSY19***	-3.37*** -0.54xTT*** -0.84xToll*** +3.45x VEHOCC*** -0.50x ROCON***	3.68*** -0.11xPSY4*** +0.14xPSY9*** -0.80xPSY12*** -0.47xPSY19***
Information Related to Model Fit						
VTTS ($/hr)	38.78	37.99	38.56	39.53	38.12	-
K (DOF)	9	16	10	17	12	16
ρ^2	0.431	0.445	0.441	0.477	0.455	0.400
$\rho^2_{adjusted}$	0.430	0.445	0.441	0.476	0.454	0.399
% Cor. Pred. Overall	53.87	55.13	54.78	60.58	56.38	54.62
% Cor. Pred. For CP-EL	0.00	12.15	12.28	29.16	28.61	20.14

- DOF=Degrees of Freedom
- ρ^2=Rho Squared Value
- $\rho^2_{adjusted}$=Adjusted Rho Squared Value
- % Cor. Pred.=Percent Correctly Predicted Value
- ***=Statistically significant at 0.01 significance level
- TT=Travel Time; VEHOCC=Vehicle Occupancy; MALE=Male; ROCON=Scale associated with Reliance on Others Construct; WEEKD=Weekday (Monday-Friday); NUMWW=Number of Workweek Trips; HINC=High Income Household (household income $100,000 or more); LOWAGE=16-34-years-old

Next, consider the Recommended B Trip and Demographic + Psychological Item Model (Model 10), that includes vehicle occupancy variables and variables associated with six psychological items of interest. Compared to the previously mentioned models you can see that the percent correctly predicted value increases quite dramatically, to over 60%, and the percent correctly predicted value for the CP-EL alternative rises to over 29%. While the Recommended Trip and Demographic + Psychological Scale Model (Model 12) is associated with an improvement over the models with just trip and demographic variables, the improvement is not as drastic as that seen in Model 10.

The Just Six Psychological Item Variables (Model 13), which were taken from the psychological variables included in Model 5, is also included in this table to help illustrate the usefulness of these items. Note that a model just containing variables related to the six psychological items that were found to be of particular interest (i.e., without the inclusion of travel time, toll, or trip and demographic variables) is associated with a model that has a lower adjusted rho squared value than that obtained from Model 1. However, the overall percent correctly predicted values of 54.62% and the CP-EL alternative percent correctly predicted value of 20.14% are both higher than the corresponding values obtained from Model 1 (Basic Model with Just Travel Time, Toll, and ASCs).

In conclusion, the results of the combined model analysis further support the finding that modeling with psychological items appears to be more useful than modeling with the psychological scales considered within this analysis. The results obtained from an analysis of the three types of models (trip and demographic, psychological items, psychological scales) and the combined models both support this finding. Additionally, the use of select psychological items, in tandem with trip and demographic variables, leads to improved results in modeling when compared to the corresponding model containing just trip and demographic variables. And, a model containing only variables associated with the six psychological items in question (i.e., not travel time, toll, or ASCs) results in a lower adjusted rho squared value but higher percent correctly values (both overall and for the CP-EL alternative) than that associated with a basic model containing only travel time, toll, and ASCs.

6.5 Impact of Income on the VTTS

VOT is often related to a traveler's income level. Naturally, the higher the household income level, the higher the expected VOT. Therefore, the best models were adjusted by changing the toll variable to toll divided by the natural log of the household income.

A variable called "MEDINC" was created and assigned to the appropriate median value associated with the household income groups. The highest household income group (i.e., household income of $100,000 or more) was open-ended. A median household income level of $200,000 was assumed for this group. The median value associated with each of the four household income groups considered is summarized in Table 26.

Table 26. Median Household Income Group Values

Range of Household Incomes ($)	Median Group Value ($)
0-24,999	12,500
25,000-49,999	37,500
50,000-99,999	75,000
100,000 or more	200,000

Equation (9) (mentioned previously and shown here again for convenience) was used in calculating the four VTTS values.

$$VTTS = 60 * \frac{c\_time}{c\_toll} * Ln(MEDINC) \qquad (9)$$

where

MEDINC=median income range in the household income category

c_time=travel time coefficient

c_toll=toll coefficient

A comparison of the two results are provided in Table 27.

Table 27. Comparison of Different Methods (Models 8-12 vs. Models 8a-12a) to Calculate VTTS for Combined Models

Model Name and Type of VTTS Calculation	Household Income Group	VTTS ($/hr)	Adjusted Rho Squared Value	Percent Correctly Predicted (Overall)	Percent Correctly Predicted (CP-EL Alternative)
Model 8-Original VTTS Method	All Household Income Groups	39.48	0.478	60.7	30.02
Model 8a-Second VTTS Method	$0-$24,999	31.65	0.476	60.61	29.47
	$25,000-$49,999	35.34			
	$50,000-$99,999	37.66			
	$100,000 or more	40.95			
Model 9-Original VTTS Method	All Household Income Groups	39.46	0.772	60.64	30.02
Model 9a-Second VTTS Method	$0-$24,999	31.62	0.476	60.44	29.14
	$25,000-$49,999	35.31			
	$50,000-$99,999	37.63			
	$100,000 or more	40.92			
Model 10-Original VTTS Method	All Household Income Groups	39.53	0.476	60.58	29.16
Model 10a-Second VTTS Method	$0-$24,999	31.74	0.474	60.35	28.53
	$25,000-$49,999	35.44			
	$50,000-$99,999	37.77			
	$100,000 or more	41.07			
Model 11-Original VTTS Method	All Household Income Groups	38.03	0.455	56.67	28.29
Model 11a-Second VTTS Method	$0-$24,999	30.45	0.454	56.62	27.96
	$25,000-$49,999	33.99			
	$50,000-$99,999	36.23			
	$100,000 or more	39.40			
Model 12-Original VTTS Method	All Household Income Groups	38.12	0.454	56.38	28.61
Model 12a-Second VTTS Method	$0-$24,999	30.63	0.453	56.4	28.29
	$25,000-$49,999	34.20			
	$50,000-$99,999	36.45			
	$100,000 or more	39.63			

For each of the original combined models (Models 8-12), the singular VTTS value obtained using the original VTTS method falls within the range of values obtained from the corresponding model created using the second VTTS method (Models 8a-Models 12a), as expected. Note that in each case, the original VTTS method value is on the high end of the range of the corresponding VTTS values obtained using the second method. This is largely a reflection of the sample being skewed to the right in terms of household income, with well over half of respondents reporting their household income to be $100,000 or more. The adjusted rho squared value is higher for the corresponding original VTTS method for each model (Models 8-12). Likewise, both the overall percent correctly predicted value and the CP-EL alternative percent correctly predicted value are higher for the model created using the original VTTS method (Models 8-12) when compared to its second VTTS method counterpart (Models 8a-12a). Therefore, although the second method of calculating VTTS provides greater insight into how different household income groups may value their time differently, it does not appear to produce a better model over the original VTTS method in terms of adjusted rho squared value and the percent correctly predicted values.

6.6 Survey Design: Comparing Db-Efficient and Adaptive Random Designs

Having created and analyzed the results of each individual type of model (i.e., trip and demographic, psychological items, and psychological scales), the next step in the analysis process was to compare the results obtained from the two different survey designs: namely DBE and AR. Such a comparison may provide insight into if SP design impacts the results, and which design may be better.

Respondents were randomly assigned to one of the two designs. Therefore, a fairly even number of responses associated with each design type would be expected, and the trip and demographic characteristics associated with the respondents from each survey type would be expected to be comparable. An overview of key trip information, SP question responses, and demographic data for all respondents (both DBE and AR responses), as well as for the DBE and AR responses individually, are provided in Table 28, Table 29, and Table 30, respectively.

Table 28. Overview of Trip Information for DBE and AR Designs

Characteristic	Study Area		
	All (%)	**DBE (%)**	**AR (%)**
TRIP INFORMATION			
Trip Purpose of Most Recent Trip on EL Corridor in Question			
Commuting (going to or from work)	74.8	74.8	74.8
Recreational/Social/Shopping/ Entertainment/Personal Errands	11.2	11.7	10.7
School	1.1	1.0	1.3
Work Related (other than between home and work)	10.6	10.5	10.7
Didn't Specify/Other	2.3	2.0	2.5
Day of Week of Most Recent Trip on EL Corridor in Question			
Sunday	1.4	1.5	1.3
Monday	8.4	8.3	8.6
Tuesday	16.3	15.9	16.6
Wednesday	27.5	26.9	28.1
Thursday	22.8	23.4	22.2
Friday	21.0	21.1	21.0
Saturday	2.4	2.7	2.0
Didn't Specify	0.2	0.2	0.2

Table 28. continued

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
Length of Trip			
Less than 2 miles	0.3	0.3	0.3
3 to 5 miles	2.9	3.3	2.5
6 to 10 miles	10.8	9.8	11.8
11 to 15 miles	17.1	17.3	17.0
16 to 20 miles	17.0	16.7	17.3
21 to 25 miles	15.6	15.7	15.5
26 to 30 miles	11.5	11.8	11.1
More than 30 miles	24.5	24.7	24.3
Didn't Specify	0.3	0.4	0.2
Number of People (including yourself) in the Passenger Car/SUV/Pick-up Truck			
1	86.2	86.7	85.7
2	10.2	9.6	10.9
3	1.5	1.4	1.7
4	1.1	1.0	1.1
5+	0.5	0.8	0.2
Didn't Specify	0.5	0.5	0.4
Were you the driver or a passenger on this recent trip? (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck, who responded to this question)			
Driver	82.0	82.7	81.4
Passenger	18.0	17.3	18.6
Who did you travel with on this recent trip? (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%)			
Co-worker/person in the same, or a nearby, office building	24.4	22.7	26.1
Neighbor	2.9	2.0	3.8
Adult family member	56.5	58.3	54.7
Child	22.5	25.3	19.8
Other	6.6	7.7	5.7

Table 28. continued

Characteristic	Study Area		
	All (%)	**DBE (%)**	**AR (%)**
How much extra time did it take to pick up and drop off the passenger(s)? (minutes) (Calculated based on % of those with 2 or more persons in the Passenger Car/SUV/Pick-up Truck, who responded to this question.)			
0	51.4	54.2	48.8
1-5	20.6	15.6	25.4
6-10	12.1	13.5	10.9
11-15	6.6	6.3	6.9
16-20	4.3	5.0	3.6
21-30	2.1	2.1	2.0
31-60	2.3	2.5	2.0
Greater than 60 (but less than 120)	0.4	0.4	0.4
Unrealistic (120)	0.2	0.4	0.0
Did you use the EL for that trip?			
Yes	68.4	67.7	69.2
No	31.4	32.2	30.6
Didn't Specify	0.2	0.1	0.2
How much travel time do you think you saved (by using the EL) compared to the GPLs? (minutes) (Calculated based on those who indicated they used the EL for that trip, who responded to this question.)			
0	2.0	1.7	2.3
1-5	28.8	29.1	28.5
6-10	29.8	30.0	29.6
11-15	19.5	19.1	19.9
16-20	11.2	10.9	11.5
21-30	6.5	6.9	6.0
31-60	2.1	2.2	2.1
Unrealistic (more than 60 minutes)	0.1	0.1	0.1
Have you ever used the EL on the EL corridor in question? (Calculated based on those who responded to the question.)			
Yes	99.4	99.5	99.4
No	0.6	0.5	0.6

Table 28. continued

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
What are the main reasons you used the EL? (Calculated based on those who said they had used the EL. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%.))			
Being able to use the EL for free as a carpool	24.0	24.2	23.8
During the peak hours the ELs will not be congested	64.0	63.8	64.2
Travel times on the ELs are consistent and predictable	37.9	37.4	38.5
The ELs are safer/less stressful than driving on the GPLs	43.9	43.8	44.1
Travel times on ELs are less than those on the GPLs	93.9	93.6	94.3
Trucks and larger vehicles are not allowed on the ELs	18.5	19.3	17.6
My employer pays for the tolls	4.4	4.6	4.0
Other	4.4	4.6	4.1
Reasons you have never used the EL (Calculated based on those who said they had not used the EL. Multiple responses could be selected by a respondent; therefore, the total sums to more than 100%.))			
Access to the ELs is not convenient for my trips	34.8	45.5	25.0
The tolls are too high for me	17.4	27.3	8.3
I can easily use other routes than the Freeway, so I'll just avoid it if I think there is a lot of traffic	26.1	27.3	25.0
The ELs do not offer me enough time savings	26.1	27.3	25.0
I do not want to pay the toll for this trip	43.5	36.4	50.0
I don't like that the toll changes based on time of day	13.0	18.2	8.3
I do not want a toll transponder in my car	4.3	9.1	0.0
I do not have a credit card so it is inconvenient to set up a toll account	4.3	0.0	8.3
I have the flexibility to travel at less congested times	21.7	18.2	25
EL use is complicated or confusing	8.7	9.1	8.3
Participation in a carpool is difficult/undesirable	13.0	27.3	0.0
Other	13.0	9.1	16.7

Table 28. continued

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
How many total trips did you make during the past full work week (Monday to Friday) on the EL corridor in question? (Each direction of travel is one trip, include trips on the EL or GPLs)			
0 trips per week	2.6	2.3	2.8
1-5 trips per week	36.1	36.5	35.6
6-10 trips per week	51.0	50.9	51.1
11-15 trips per week	7.9	8.0	7.8
16-20 trips per week	1.6	1.6	1.8
21 or more trips per week (but no more than 60 trips)	0.6	0.5	0.7
Didn't Specify/Unrealistic (more than 60 trips)	0.2	0.2	0.2
How many of those trips were using the EL?			
0 trips per week	9.6	9.7	9.6
1-5 trips per week	56.5	57.2	55.9
6-10 trips per week	28.9	28.4	29.4
11-15 trips per week	2.1	2.1	2.0
16-20 trips per week	0.3	0.2	0.4
21 or more trips per week (but no more than 60 trips)	0.2	0.1	0.2
Didn't Specify/Unrealistic Answer (decimal or more than 60 trips)	2.4	2.3	2.5
How many of those trips would you say you were unusually pressed for time or had a tight schedule?			
0 urgent trips per week	25.3	25.8	24.8
1-5 urgent trips per week	59.4	58.9	60.1
6-10 urgent trips per week	10.0	10.7	9.2
11-15 urgent trips per week	0.8	0.6	0.9
16-20 urgent trips per week	0.2	0.1	0.3
21 or more trips per week	0.1	0.1	0.1
Didn't Specify/Unrealistic Answer (decimal)	4.2	3.8	4.6

Table 28. continued

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
Think about those trips that you were pressed for time. What percentage of the time did you use the ELs for those trips? (Calculated based on % of respondents who answered this question)			
Never use the EL for those urgent trips	0.2	0.2	0.3
Rarely use the EL for those urgent trips	2.8	3.6	2.0
About half the time I use the EL for those urgent trips	12.7	12.5	12.9
Most of my urgent trips are on the EL	25.8	25.2	26.4
Always use the EL for those urgent trips	58.5	58.5	58.4
On average, how much did you pay for the toll for a typical trip on the EL? (Calculated based on % of respondents who answered this question)			
Less than $1.00	29.4	30.2	28.5
$1.01 to $3.00	46.0	45.0	47.1
$3.01 to $5.00	11.8	11.8	11.9
More than $5.00	2.7	2.8	2.5
Do not remember	6.0	6.3	5.7
$0. I am a toll free user so I did not pay a toll	4.1	3.9	4.3
Approximately how much time did you save by using the EL? (Calculated based on % of respondents who answered this question)			
0 minutes	0.7	0.8	0.7
1-5 minutes	17.9	17.6	18.2
6-10 minutes	26.6	26.9	26.3
11-15 minutes	18.8	18.3	19.3
16-20 minutes	11.4	10.7	12.2
21-30 minutes	8.6	8.6	8.5
31-60 minutes	9.2	9.5	8.9
More than 60 minutes (but no more than 600 minutes)	6.8	7.6	5.8
Unrealistic (more than 600 minutes)	0.0	0.0	0.1

Table 29. Overview of the Stated Preference Responses for DBE and AR Designs

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
SP RESPONSES			
Responses to SP Travel Choice Question 1			
DA-GPL	47.0	45.8	48.3
CP-GPL	1.0	1.2	0.8
DA-EL	34.8	36.5	33.1
CP-EL	17.2	16.5	17.8
Respondents to SP Travel Choice Question 2			
DA-GPL	50.8	48.5	53.2
CP-GPL	1.0	1.0	1.0
DA-EL	32.9	35.3	30.3
CP-EL	15.3	15.2	15.5
Respondents to SP Travel Choice Question 3			
DA-GPL	48.5	49.5	47.4
CP-GPL	0.7	0.6	0.9
DA-EL	35.1	33.2	37.0
CP-EL	15.7	16.7	14.7

Table 30. Overview of the Demographic Data for DBE and AR Designs

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
DEMOGRAPHIC DATA			
What is your age?			
16 to 24	0.9	0.7	1.0
25 to 34	15.4	14.7	16.2
35 to 44	24.7	24.4	25.1
45 to 54	28.1	27.9	28.4
55 to 64	22.3	23.6	20.9
65 and over	7.8	7.9	7.6
Didn’t Specify	0.8	0.8	0.8

Table 30. continued

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
What is your gender? (% of respondents who answered this question)			
Male	56.7	56.7	56.8
Female	41.2	41.4	40.9
Didn't Specify	2.1	1.9	2.3
Please describe the type of household you live in.			
Single Adult	15.9	15.4	16.4
Unrelated adults	2.7	2.6	2.9
Married without children	20.9	20.2	21.6
Married with child(ren)	53.3	54.7	51.8
Single parent family	4.7	4.5	4.9
Other/Didn't Specify	2.5	2.6	2.4
Is your child(ren) between 5 to 17 years old (school age)? (Calculated based on % of respondents who answered this question)			
Yes	58.9	57.6	60.2
No	41.1	42.4	39.8
Including yourself, how many people live in your household?			
1	12.0	12.4	11.5
2	34.5	32.6	36.6
3	17.1	18.1	16.1
4	19.5	19.5	19.4
5+ (up to 20 people)	15.9	16.4	15.5
Didn't Specify/Unrealistic (0 people or greater than 20 people)	1.0	1.0	0.9
All together, how many motor vehicles (including cars, vans, trucks, and motorcycles) are available for use by members of your household?			
1	11.3	11.1	11.6
2	45.3	45.6	45.1
3	24.9	24.4	25.4
4	11.1	11.4	10.8
5+ (but not greater than 10 vehicles)	6.2	6.2	6.2
Didn't Specify/Unrealistic (greater than 10 vehicles)	1.2	1.3	0.9

Table 30. continued

Characteristic	Study Area		
	All (%)	DBE (%)	AR (%)
What category best describes your occupational or work status?			
Professional/Managerial	56.1	56.1	56.0
Technical	9.9	9.8	10.1
Sales	7.4	7.6	7.3
Administrative/Clerical	5.7	5.6	5.9
Manufacturing	0.7	0.8	0.6
Stay-at-home homemaker/parent	0.7	0.7	0.6
Student	1.0	0.6	1.3
Self employed	6.7	6.7	6.7
Unemployed/Seeking work	0.7	0.7	0.6
Retired	3.4	3.5	3.3
Educator	3.0	3.1	2.9
Other/Didn't Specify	4.7	4.8	4.7
What was the last year of school that you have completed?			
Less than high school	0.3	0.3	0.3
High school graduate	2.8	2.7	2.9
Some college or vocational school	20.4	21	19.7
College graduate	44.1	43.2	45.0
Postgraduate degree	30.8	31.4	30.3
Other/Didn't Specify	1.6	1.4	1.8
What was your gross annual household income before taxes in 2013?			
Less than $10,000	0.3	0.3	0.4
$10,00 to $14,999	0.3	0.2	0.3
$15,000 to $24,999	0.7	0.7	0.7
$25,000 to $34,999	1.7	1.4	1.9
$35,000 to $49,999	5.1	5.0	5.2
$50,000 to $74,999	13.1	13.1	13.1
$75,000 to $99,999	16.5	16.0	17.0
$100,000 to $199,999	39.0	39.5	38.6
$200,000 or more	19.6	19.6	19.6
It's easier to tell hourly wage rate	0.5	0.6	0.4
Didn't Specify	3.2	3.6	2.8

As shown in Tables 28-30, the trip information, stated preference responses, and demographic information associated with the two design types were very similar. The next step in the DBE versus AR comparison was to compare the percent of respondents associated with each design type in terms of non-trading behavior and lexicographic behavior. Again, based on the results summarized in Tables 28-30, any difference in the non-trading and lexicographic analyses are likely due to SP design and not different characteristics of the respondents in each group.

As the name implies, non-trading occurs when a respondent selects the same alternative for all three SP questions. Lexicographic behavior is associated with respondents fixating on a specific attribute (i.e., travel time, toll) when they make their SP decision (Harline 2013). Examples of lexicographic behavior include always selecting the fastest travel time or always choosing the cheapest option. A summary of non-trading and lexicographic behavior observed within this analysis is provided in Table 31.

Table 31. Non-Trading and Lexicographic Behavior Comparison for Different Design Types

Behavior Type	**All (%)**	**DBE (%)**	**AR (%)**
Non-Trading Behavior	47.71	51.81	43.44
Lexicographic Behavior: Fastest Travel Time (DA-EL or CP-EL because EL travel time lower than GPL time)	28.01	30.86	25.05
Lexicographic Behavior: Cheapest Option (DA-GPL, CP-GPL, or CP-EL because these options are free)	40.87	43.02	38.64

A z test for two population proportions (also sometimes called a two-sided, two-sample t-test between proportions) was performed for each type of behavior (i.e., non-trading, fastest travel time, and cheapest option) to statistically compare the proportions displayed in

Table 31. The null hypothesis was that the two proportions were equal and the z statistic used in the test was calculated using Equation (11) (Stangroom 2015).

$$z = \frac{\bar{p}_{DBE} - \bar{p}_{AR} - 0}{\sqrt{\bar{p}(1-\bar{p})\left(\frac{1}{n_{DBE}} + \frac{1}{n_{AR}}\right)}} \quad (11)$$

where

$\bar{p}_{DBE}$=proportion of DBE respondents with a given non-trading or lexicographic behavior

$\bar{p}_{AR}$= proportion of AR respondents with a given non-trading or lexicographic behavior

$\bar{p}$=proportion of all respondents with a given non-trading or lexicographic behavior

n_{DBE}=number of DBE respondents

n_{AR}=number of AR respondents

For each case (i.e., non-trading, fastest travel time, and cheapest option), the percent respondents exhibiting the non-trading or lexicographic behavior in question was statistically significantly higher for the respondents assigned the DBE design at the 0.05 significance level. It is not surprising that non-trading behavior is lower for the AR design. Patil et al. (2011) also found the AR design to be associated with less non-trading, and fewer cases of always selecting the cheapest option; though their comparison considered not only an efficient design and an AR design, but a random attribute design as well. Within the AR design, the toll shown on the next SP question is reduced by 15 to 50 percent if the respondent did not select the tolled alternative, and is increased by 15 to 75 percent if the respondent chose the tolled alternative. Thus, it makes sense that fewer respondents continue to select the same alternative across all three SP questions for the AR design (i.e., exhibit non-trading), because the design adapts to respondents' choices in a way that encourages choosing a different mode (trading). As with non-trading behavior, it is not surprising that the AR design was also associated with a lower percentage of respondents always selecting a mode with the fastest travel time or always choosing a mode that is among the cheapest options. Again, this likely has ties to the adaptive nature (as the name implies) of the AR design.

Next, the VTTS, adjusted rho squared value, and percent correctly predicted values associated with the DBE and AR designs were compared. The goal was to determine whether either or both design types resulted in a reasonable VTTS, and which design had the higher adjusted rho squared value and higher percent correctly predicted values. The comparison was performed by running Models 8-12 (the combined models of interest) in NLOGIT again, once with the respondents who received the AR design and once with the respondents who received the DBE design. A summary of the VTTS, adjusted rho squared value, and percent correctly predicted values (both overall and for the CP-EL alternative) for these models is presented in Table 32.

Table 32. Comparison of VTTS, Adjusted Rho Squared Value, and Percent Correctly Predicted Values by Design Type

Model	Model Type	VTTS ($/hr)	Adjusted Rho Squared Value	Overall Percent Correctly Predicted Value (%)	CP-EL Percent Correctly Predicted Value (%)
Model 8: Baseline Trip/Dist and Psy Items Model	All	39.48	0.478	60.70	30.02
	DBE	42.20	0.495	62.21	27.40
	AR	38.34	0.460	59.52	32.06
Model 9: Recommended A Trip/Dist and Psy Items Model	All	39.46	0.477	60.64	30.02
	DBE	42.27	0.495	62.09	27.22
	AR	38.18	0.460	59.42	31.78
Model 10: Recommended B Trip/Dist and Psy Items Model	All	39.53	0.476	60.58	29.16
	DBE	42.42	0.494	61.78	25.55
	AR	38.44	0.459	59.21	30.93
Model 11: Baseline Trip/Dist and Psy Scales 56.38Model	All	38.03	0.455	56.67	28.29
	DBE	40.65	0.474	58.69	25.88
	AR	36.11	0.439	53.97	29.63
Mod58.66el 12: Recomme53.84nded Trip/Dist and Psy Scales Model	All	38.12	0.454	56.38	28.61
	DBE	40.78	0.474	58.66	25.62
	AR	36.21	0.437	53.84	30.56

For a given model, the VTTS is higher (by between 10% and 13%) for the DBE design than for the AR design. However, the VTTS associated with both designs seem reasonable. When comparing the adjusted rho squared values for the two types of designs, the DBE design results in a higher value than the AR design for a given model.

This finding of the efficient design being associated with a higher adjusted rho squared value than the AR design differs from what was found by Patil et al. (2011). In terms of overall percent correctly predicted value, the DBE design value is higher than its AR design counterpart. However, when considering just the CP-EL alternative percent correctly predicted value, the AR designs perform better.

In summary, it appears that in terms of non-trading and lexicographic behavior, the AR design performs better (i.e., has lower occurrences of non-trading, or always selecting a mode that is among the fastest or cheapest option) at a statistically significant rate (at a 0.05 significance level) than the DBE design. Both designs are comparable in terms of VTTS, with both designs producing reasonable values and the DBE design VTTS being slightly higher for a given model. In terms of the adjusted rho squared value, the DBE design results in a higher value than the AR design, for a given model. As for the percent correctly predicted values, the DBE design performs better overall, while the AR design performs better in terms of the CP-EL percent correctly predicted value for a given model. Neither the DBE design nor the AR design performs superior in all areas of comparison.

6.7 Summary of Data Analysis and Results

The data analysis performed as part of the present research effort consisted of several parts. First the data were summarized by area. Then, the SP responses versus key demographic data, trip information, and psychological items were considered. The summaries were followed by statistical tests of an exploratory nature. ANOVA test procedures to compare the mean psychological item response by mode, Kruskal-Wallis test procedures to compare the mean rank for psychological items by mode, and ordinal regression models (logit link) to compare the mean psychological item response by mode using log odd ratios, were performed. The results obtained from these three groups of exploratory tests largely produced similar results in terms of psychological items that showed promise in potentially being of use in subsequent discrete choice modeling. Correlations were considered at various states in the process of performing discrete choice modeling.

A variety of MMNLs were created using NLOGIT (Greene (c) 1986-2012). The criteria used to evaluate the models included VTTS, adjusted rho squared value, and percent correctly predicted values (both overall and for the CP-EL alternative). Initially, models either including trip and demographic characteristics, psychosocial items, or psychological scales were created. This was followed by the creation of combined models that included trip and demographic characteristics and either psychological items or psychological scales. The inclusion of select psychological items appear to be more useful in modeling when compared to psychological scales. Overall, models associated with trip and demographic variables, and psychological item variables, showed the most promise. Also note that a model (Model 13) including just ASCs and select psychological items (i.e., excluding travel time and toll) was associated with higher percent correctly predicted values (both overall and for the CP-EL alternative) than the basic model with just travel time, toll, and ASCs (Model 1), though with lower adjusted rho squared values (both original and adjusted).

Two different methods of assessing VTTS were considered for the five combined models discussed in the present research, with the original method corresponding to Models 8-12 and the second method corresponding to Models 8a-12a. The second method allows for different VTTS values to be calculated for different household income groups. While this second method provided for multiple VTTS values to be calculated, the models produced using this method led to a lower adjusted rho squared values and lower percent correctly predicted values (overall and for the CP-EL alternative) than their original method VTTS calculation model counterparts.

A comparison of the DBE and AR design types led to mixed results as to which design is "better". For a given combined model, the following results were noted:

- Not surprisingly, the AR design was associated with a lower level of non-trading, as well as a lower percentage of respondents always picking from among the fastest options or always picking from among the cheapest options (i.e., free options).
- The VTTS associated with both design types were reasonable, though the DBE design VTTS was slightly higher for a given model.
- The DBE design led to a higher adjusted rho squared value and a higher percent correctly predicted value, though the AR design led to a higher percent correctly predicted value for the CP-EL alternative.

Based on these results, there does not appear to be a clear-cut superior design type when comparing DBE and AR designs.

7. CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

Within this chapter, a summary of the conclusions drawn from the present study is provided. Additionally, a discussion on some of the research limitations is included, along with recommendations for future research.

7.1 Conclusions

Travel time and toll are clearly not the only characteristics affecting lane choice and carpooling decisions made in a ML context. Preliminary research performed by Burris et al. (2012a) and Green and Burris (2014) began to address the possibility that psychological characteristics may contribute to a clearer understanding of travel behavior decisions in ML settings. The present study built on previous research and improves on it with the development of a set of psychological items that are largely framed in a transportation context.

Efforts were made to measure psychological constructs (i.e., in this case, psychological attributes of interest) by developing tests and scales (i.e., groups of related items) that represent them. However, the results of the analysis show that more information related to transportation decisions made in ML settings (i.e., lane choice and/or carpooling decisions) can be gained from using select psychological items in modeling, than in using the scales developed for this analysis. More specifically, the following six psychological items were found to be especially useful in predicting mode choice:

- **Psychological Item #2 (DA-GPL<DA-EL):** Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.
- **Psychological Item #4 (CP-EL<DA-GPL<DA-EL):** When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.
- **Psychological Item #9 (DA-EL<DA-GPL<CP-EL):** I cannot understand why someone would pay to use the express lane when the general purpose lanes are available for free, especially when it may or may not save time.
- **Psychological Item #10 (DA-EL<DA-GPL):** I only choose to use the express lane if the general purpose lanes seem crowded.
- **Psychological Item #12 (CP-GPL<DA-GPL; CP-EL<DA-GPL):** The coordination involved with carpooling is more hassle than it is worth.
- **Psychological Item #19 (CP-GPL<DA-GPL; CP-EL<DA-GPL):** I do not like relying on others for rides.

Note that five of the six items (psychological items 2, 9, 10, 12, and 19) have direct ties to ELs or carpooling. Thus, it appears that the level to which a given psychological item relates to EL use and carpooling may have affected its usefulness in modeling—potentially masking some of the information that the psychological scales in question may have provided.

The goal driving the creation of the recommended models mentioned within the present study was to produce a model that could model the use of MLs through the use of limited items, so as to be able to recommend a reduced list of psychological items to potentially include in a future traffic and revenue estimating survey. Therefore, one of the limitations associated with the psychological scale models is the difficulty in deriving small, incremental improvements because with the inclusion of each additional scale to the model, the number of psychological items associated with the model increases by three to six items. In other words, the psychological scale models lack the flexibility associated with the psychological item models, where one item can be added at a time.

In terms of trip and demographic items, vehicle occupancy during the respondent's most recent trip in the EL corridor in question proved to be the most useful item—with those who reported higher vehicle occupancy having a higher likelihood of selecting one of the carpooling alternatives (CP-GPL or CP-EL) than the DA-GPL alternative. This is not surprising given the obvious connection between vehicle occupancy and carpooling. Other trip and demographic variables that showed particular promise in predicting mode choice included young travelers (16-34-year-olds) having a higher likelihood of selecting the CP-EL alternative than the DA-GPL alternative and males having a lower likelihood of selecting the DA-EL alternative than the DA-GPL alternative. The combined models (i.e., combining trip and demographic variables and psychological item variables, and combining trip and demographic variables and psychological scale variables) resulted in better models than the two types of models produced individually. The improvement in the CP-EL alternative percent correctly predicted value was especially noticeable when comparing the trip and demographic models with the combined models that included the addition of either psychological item variables or psychological scale variables. The best combined models included variables from the trip and demographic and psychological item category.

The results of the present study may be of particular interest to transportation planners and traffic and revenue estimating firms considering the potential addition of items to future surveys that could help to improve planning associated with EL corridors. It is not possible to weight the psychological item responses obtained from a survey to a whole population of users, as is often done with trip and demographic characteristics. However, the results of the present study indicate that psychological items—especially those directly related to carpooling or EL use—may be of more use than many commonly used trip and demographic items in predicting travel behavior in EL settings (be it lane choice and/or carpooling decisions), despite not being able to weight the psychological items to the population of users. It is recommended that the six psychological items noted above (namely psychological items 2, 4, 9, 10, 12, and 19) be used as a starting point to improve the ML planning process.

Additionally, based on the results of this research, performing a short travel survey that includes just stated preference questions and these six psychological items can lead to better modeling of travel behavior (in terms of adjusted rho squared value and percent correctly predicted value) than more extensive surveys that include questions related to commonly used trip and demographic questions. And, when used in tandem with common trip and demographic variables, these six psychological items lead to an improved model (in terms of adjusted rho squared value and percent correctly predicted value) compared to either variable type considered separately.

These findings constitute some of the major contributions derived from the present research study, and offer agencies insight into a novel way to improve the planning of their MLs. The interpretation associated with each of the six psychological items of particular interest is summarized in Table 33.

Table 33. Summary of Findings Associated with Recommended Six Psychological Items

Psychological Item Number and Description	Findings Associated with Those Who Agreed with This Statement
PSY2: Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.	• DA-EL>DA-GPL • Hints at the idea that people who use the EL may do so looking ahead to the possibility that congestion could occur, even if at the time they choose to use the EL, congestion may or may not be present. • Supports idea that some people who choose to drive alone in the EL do so out of anticipation of potential congestion, in an effort to think ahead, and not necessarily because current conditions warrant the decision.
PSY4: When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	• CP-EL < DA-GPL < DA-EL • Double-barreled in nature—speaking to both convenience and price. • "Not paying much attention to price" may be highly correlated with the sentiment that "my household income is fairly high, so I do not need to worry much about the cost of the EL". This hypothesis is supported by the fact that the average Likert scale response obtained for PSY4 was higher for respondents associated with a higher household income level. • Analysis related to the relationship between carpooling convenience for drivers of carpools and their PSY4 response did not provide support for the hypothesized relationship between valuing convenience and bypassing carpooling. Further analysis in this area may be insightful.
PSY9: I cannot understand why someone would pay to use the express lane when the general purpose lanes are available for free, especially when it may or may not save time.	• DA-EL<DA-GPL<CP-EL • DA-EL<DA-GPL result is not surprising. • CP-EL>DA-GPL may at first seem surprising, but recall that the CP-EL alternative is free (with varying vehicle occupancy requirements), so the CP-EL alternative is not as directly tied to the statement as the DA-EL alternative.

Table 33. continued

Psychological Item Number and Description	Findings Associated with Those Who Agreed with This Statement
PSY10: I only choose to use the express lane if the general purpose lanes seem crowded.	• DA-EL<DA-GPL • The result may at first seem in contrast to the PSY2 result, but it seems that the *timeframe* associated with the item is important. This item relates to *curren*t conditions; whereas PSY2 relates to *future* conditions. • This item is partially confounded by the fact that the "most recent trip" is associated with different levels of congestion for different respondents.
PSY12: The coordination involved with carpooling is more hassle than it is worth.	• CP-GPL<DA-GPL • CP-EL<DA-GPL • These results are not surprising given the close tie of the item to carpooling.
PSY19: I do not like relying on others for rides.	• CP-GPL<DA-GPL • CP-EL<DA-GPL • These results are not surprising given the close tie of the item to carpooling.

In comparing the two design types (DBE and AR), each design performed superior in different aspects of what was analyzed. The VTTS values obtained from each type of design were comparable, and both seem reasonable. For a given model, the DBE design resulted in a higher adjusted rho squared value and a higher overall percent correctly predicted value. However, the AR design resulted in a higher CP-EL alternative percent correctly predicted value, which is often a difficult mode to predict. Additionally, the AR design exhibited less non-trading and lexicographic behavior (i.e., always choosing the fastest option or always choosing the cheapest option).

7.2 Research Limitations

The analysis performed in the present study was based on a large sample size. However, only responses obtained from SLC, DC, and Minn were used in the analysis.

Working with local transportation professionals to advertise the survey via electronic newsletter seemed to be highly correlated with the responses obtained in SLC, DC, and Minn—especially in the case of SLC and Minn. Either selecting additional cities for inclusion in the survey, or convincing Seattle and LA to participate in a similar advertisement set-up may have resulted in an even larger sample size. However, despite the poor response in some of the study areas, the sample size that was obtained for the present study—along with the fact that all respondents were asked to answer all 25 psychological items, rather than only being shown a portion of the psychological items—allowed for a larger sample to be available during the model creation process than was available in previous work done by Burris et al. (2012a) and Green and Burris (2014).

7.3 Suggestions for Future Research

Based on the results of this research, the use of select psychological items proved to be more useful in modeling ML choices than the psychological scales that were considered. Thus, efforts to expand on the recommended list of psychological items to potentially include in a future traffic and revenue estimating firm survey could be worthwhile. Based on both the exploratory statistical analysis tests (see Table 12), and the recommended list of psychological items to potentially include in a future traffic and revenue estimating firm survey, it appears that some of the ability to analyze psychological traits may be related to how directly an item relates to carpooling and ELs—with items tied more explicitly to carpooling or ELs often being more useful. Not accounting for this hypothesized effect may thwart efforts to fairly assess the effect of psychological traits on ML decisions. Thus, the creation of additional psychological items could be undertaken, with the ability to assess the extent to which this hypothesis is true, being the driving force.

Also, it would be interesting to create separate models for the SLC and Minn responses, to see if the same variables would be most useful in modeling across each city, or if local differences exist. This type of comparison could be extended even further if a larger sample could be obtained for the study areas that experienced varying degrees of poor response rates (Seattle, LA, and DC), or if the survey were expanded to include additional cities with EL corridors.

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APPENDIX A

ITEM SORT FORM

Item Sort Form

Personal characteristics are traits possessed by individuals and expressed through their opinions and decisions. Please read each of the following definitions of categories of personal characteristics:

- **A. Reliance on Others:** Tendency to choose, or tendency to avoid, relying on other people: general feelings toward relying on others. In transportation, this characteristic may be expressed in carpooling opinions or practices.
- B. **Control of Situations and Destiny:** View on one's ability, or lack of ability, to shape and predict the consequences of one's actions. In transportation, this characteristic may be expressed in how closely people feel their decisions related to travel mode (vehicle used), time of trip, etc., may impact travel-related outcomes.
- C. **Desire for Predictability, Reliability and Consistency:** Tendency toward, or away from, situations where the outcome is known. In transportation, this characteristic may be expressed in people's desire, or lack thereof, to select a travel mode, time of trip, etc. that leads to a predictable outcome.
- D. **Tendency to Take Risks:** Tendency to choose or avoid a gamble in the face of an unknown outcome. This is further broken into the subcategories of 1) purely financial and 2) transportation related (excluding purely financial). In a purely financial sense, this characteristic may be expressed in one's tendency to gamble money. In a transportation setting, this characteristic may be expressed in one's tendency to gamble commodities other than money itself (i.e., safety, time, etc.).
- **E. Analytical Tendency in Decision Making Process:** Tendency to think ahead, and/or analyze available information, prior to making decisions, as compared to making last minute decisions. In transportation, this characteristic may be expressed in one's thought process when deciding when to travel, which route to take, etc.

The left column lists decisions or behaviors that may be experienced. Read each decision/behavior and select the category that you think the statement *most closely* represents. Please indicate your selection by marking an "x" in the appropriate cell.

Note: A "managed lane" refers to a lane that can only be used by vehicles meeting a certain criteria. Two common types of managed lanes include High Occupancy Vehicle (HOV) lanes (where vehicles with at least a certain number of people—for example, vehicles with 2+ occupants—can use the lane for free) and High Occupancy Toll (HOT) lanes (where vehicles with at least a certain number of people can use the lane for free and others can pay a toll to use the lane).

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
Example: I enjoy playing a large lottery.				x		
1. It does not matter if I choose the general purpose lane or managed lane since it is just luck if the managed lane saves me time.						
2. Unless there is no traffic on the freeway, I choose the managed lane since traffic could become congested at any time.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
3. If I were listening to the radio and heard there is an accident on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.						
4. I only choose to use the managed lane if the general purpose lane seems crowded.						
5. When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.						
6. I have often found that what is going to happen will happen.						
7. I usually choose to use the managed lane only at the last second, after observing freeway traffic for as long as I can.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
8. I feel that the government ultimately controls the quality of travel options available to me.						
9. No matter when I leave for work I always seem to be stuck in traffic.						
10. Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.						
11. Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.						
12. I would rather walk for 20 minutes than plan on being picked-up by someone who is often 10 to 20 minutes late.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
13. It does not seem to matter when I leave for work because my commute time seems to be affected by random, unpredictable events anyway.						
14. Choosing to use the managed lane, knowing there is a 50 percent chance it will not save me time.						
15. Before purchasing a new vehicle, I spend an extensive amount of time researching potential makes, models, and prices before making a decision.						
16. If pulled over by a police officer, I do not try to talk my way out of a ticket since it will not help.						
17. If I were to carpool, my carpool partner(s) would have to be very dependable.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks: Purely Financial	Tendency to Take Risks: Transportation Related (Excluding Purely Financial)	Analytical Tendency in Decision Making Process
18. I hate to change my plans at the last minute.						
19. I cannot understand why someone would pay to use the managed lanes when the general purpose lanes are available for "free", especially when it may or may not save time.						
20. I rarely complain about traffic problems because that will not help fix the problem.						
21. Investing 10% of your annual income in a blue chip stock.						
22. I hate unexpectedly discovering ice on my windshield in the morning when I am on my way to work.						
23. I do not bother wearing a seat-belt because I figure I will get injured no matter what in the case of a bad accident.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
24. I enjoy the exhilaration of being in unpredictable situations.						
25. The coordination involved with carpooling is more hassle than it is worth.						
26. When taking a road trip, I map out the route I will follow prior to beginning the trip.						
27. Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.						
28. Lending a friend the money needed to purchase a $20 toll tag so they could use the managed lane.						
29. I often look up information about traffic conditions prior to driving anywhere.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
30. The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.						
31. Taking a job where you get paid exclusively on a commission basis.						
32. I tend to make choice about which road to use based on the traffic I encounter.						
33. I would rather consistently have a 20 minute commute than a commute that varies anywhere from 10 minutes to 30 minutes.						
34. Lending a friend an amount of money equivalent to one month's income.						
35. I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
36. When the reliability of transit system schedules is questionable, it deters me from using transit.						
37. Fluctuations in gas prices have a large impact on how much I drive.						
38. I generally choose to use managed lanes when I feel it is the only way I will make it to my destination on time.						
39. I regularly get my oil changed to prevent my vehicle from being in bad repair.						
40. I listen to the radio while driving so I can get updates on traffic.						
41. Betting a day's income at the horse races.						
42. I never try using a newly completed transit system without speaking with someone who has used it before.						

Decisions/ Behaviors	Reliance on Others	Control of Situations and Destiny	Desire for Predictability, Reliability, and Consistency	Tendency to Take Risks		Analytical Tendency in Decision Making Process
				Purely Financial	Transportation Related (Excluding Purely Financial)	
43. I do not like relying on others for rides.						

APPENDIX B

PAPER SURVEY

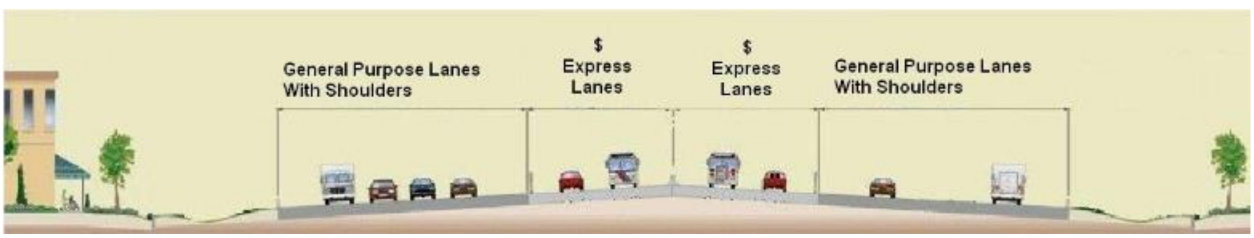
Stated Preference Questions

Each of the following questions will ask you to choose between two potential travel choices on a managed lane corridor. Please put an "X" in the box next to the one option that you would be most likely to choose if faced with these specific options. Remember that carpooling may require added travel time to pick up or drop off your passenger(s).

Please select one option for each question (i.e., **answer all three questions**) by putting an "X" inside the box beside your choice.

Note: A "managed lane" refers to a lane that can only be used by vehicles meeting certain criteria. Two common types of managed lanes include the following:

- **High Occupancy Vehicle (HOV) lanes**: Where vehicles with at least a certain number of people—for example vehicles with 2 or more occupants—can use the lane for free.
- **High Occupancy Toll (HOT) lanes**: Where vehicles with at least a certain number of people can use the lane for free, plus others can pay a toll to use the lane.



Note: General Purpose Lanes are regular freeway lanes.

Question 1

If you had the options below for your morning commute during rush hour, which would you choose?

Drive Alone on General Purpose Lanes
No Toll
Travel Time: **40** minutes

Drive Alone on Managed Lanes
Toll: **$5.00**
Travel Time: **18** minutes

Carpool on General Purpose Lanes
No Toll
Travel Time: **40** minutes

Carpool on Managed Lanes
No Toll
Travel Time: **18** minutes

Question 2

If you had the options below for your morning commute during rush hour, which would you choose?

Drive Alone on General Purpose Lanes
No Toll
Travel Time: **30** minutes

Drive Alone on Managed Lanes
Toll: **$2.00**
Travel Time: **20** minutes

Carpool on General Purpose Lanes
No Toll
Travel Time: **30** minutes

Carpool on Managed Lanes
No Toll
Travel Time: **20** minutes

Question 3

If you had the options below for your morning commute during rush hour, which would you choose?

Drive Alone on General Purpose Lanes
No Toll
Travel Time: **45** minutes

Drive Alone on Managed Lanes
Toll: **$8.00**
Travel Time: **25** minutes

Carpool on General Purpose Lanes
No Toll
Travel Time: **45** minutes

Carpool on Managed Lanes
No Toll
Travel Time: **25** minutes

Psychological Questions

Please rate the extent to which you agree with each statement using the following scale:

Strongly disagree	Disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7	8	9

Note: These are destined for travelers who live near managed lanes. If you can't answer managed lane questions (like #1 and #2) just skip them.

1.	It does not matter if I choose the general purpose lane or managed lane since it is just luck if the managed lane saves me time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
2.	Unless there is no traffic on the freeway, I choose the managed lane since traffic could become congested at any time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
3.	If I were listening to the radio and heard there is an accident on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
4.	I only choose to use the managed lane if the general purpose lane seems crowded.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
5.	When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
6.	I have often found that what is going to happen will happen.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
7.	I usually choose to use the managed lane only at the last second.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
8.	Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
9.	Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
10.	Before purchasing a new vehicle, I spend an extensive amount of time researching potential makes, models, and prices before making a decision.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
11.	If pulled over by a police officer, I do not try to talk my way out of a ticket since it will not help.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
12.	If I were to carpool, my carpool partner(s) would have to be very dependable.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
13.	I cannot understand why someone would pay to use the managed lanes when the general purpose lanes are available for "free", especially when it may or may not save time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
14.	I rarely complain about traffic problems because that will not help fix the problem.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Strongly disagree	Disagree	Somewhat disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Somewhat agree	Agree	Strongly agree
1	2	3	4	5	6	7	8	9

15.	The coordination involved with carpooling is more hassle than it is worth.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
16.	When taking a road trip, I map out the route I will follow prior to beginning the trip.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
17.	Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
18.	I often look up information about the traffic conditions prior to driving anywhere.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
19.	The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
20.	I tend to make choices about which road to use based on the traffic I encounter.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
21.	I would rather consistently have a 20 minute commute than a commute that varies anywhere from 10 minutes to 30 minutes.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
22.	I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
23.	When the reliability of transit system schedules is questionable, it deters me from using transit.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
24.	I generally choose to use the managed lanes when I feel it is the only way I will make it to my destination on time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
25.	I listen to the radio while driving so I can get updates on traffic.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
26.	I do not like relying on others for rides.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

For each of the following statements, please indicate your likelihood of engaging in each activity. Provide a rating from 1 to 9, using the following scale:

Extremely unlikely	Unlikely	Somewhat unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Somewhat likely	Likely	Extremely Likely
1	2	3	4	5	6	7	8	9

27.	Choosing to use the managed lane, knowing there is a 50 percent chance it will not save me time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
28.	Investing 10% of your annual income in a blue chip stock.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
29.	Lending a friend the money needed to purchase a $20 toll tag so they could use the managed lane.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
30.	Taking a job where you get paid exclusively on a commission basis.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
31.	Lending a friend an amount of money equivalent to one month's income.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
32.	Betting a day's income at the horse races.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

APPENDIX C

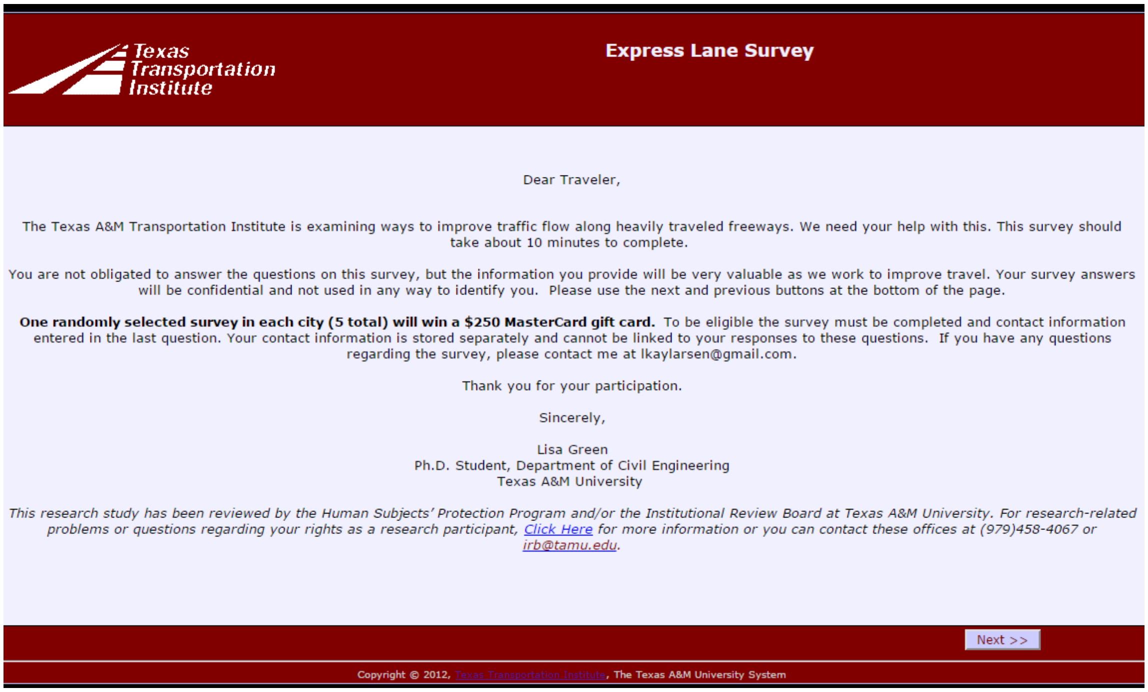
NGENE CODE

```
(a)Design
(b)Choice situation
(c)cp2ml.spdlvl_m
(d)daml.spdlvl_m
(e)daml.tlvl
(f)cpgl.spdlvl_g
(g)dagl.spdlvl_g
(h) Block

(a)   (b)     (c)    (d)    (e)   (f)    (g)    (h)
 1     1      65     65     67.5  25     25     3
 1     2      62.5   62.5   75    35     35     1
 1     3      60     60     45    25     25     4
 1     4      65     65     67.5  35     35     3
 1     5      55     55     67.5  45     45     1
 1     6      57.5   57.5   60    25     25     2
 1     7      57.5   57.5   45    40     40     2
 1     8      57.5   57.5   60    30     30     1
 1     9      60     60     75    30     30     5
 1     10     65     65     90    40     40     4
 1     11     62.5   62.5   90    45     45     2
 1     12     60     60     90    30     30     3
 1     13     62.5   62.5   45    35     35     4
 1     14     55     55     75    40     40     5
 1     15     55     55     60    45     45     5
||||||||||
Design
;alts=dagl,cpgl,daml,cp2ml
;rows=15
;block=5
;eff=(rppanel,d)
;rep=1000
;rdraws=halton(400)
;cond:
if(cp2ml.spdlvl_m <> daml.spdlvl_m , cp2ml.spdlvl_m = daml.spdlvl_m)
,if(cpgl.spdlvl_g <>
dagl.spdlvl_g,cpgl.spdlvl_g=dagl.spdlvl_g)
;model:
U(cp2ml)=c3[-0.38]+spd[n,0.14,0.64]*spdlvl_m[55,57.5,60,62.5,65]
/
U(daml)=c2[-1.90]+spd*spdlvl_m+toll[n,-0.12,0.1]*tlvl[45,60,67.5,75,90]
/
U(cpgl)=c1[-4.25]+spd*spdlvl_g[25,30,35,40,45]
/
U(dagl)=spd*spdlvl_g
$
```

APPENDIX D

SURVEY (AS SEEN BY RESPONDENTS IN LIMESURVEY)



Texas Transportation Institute

Express Lane Survey

Dear Traveler,

The Texas A&M Transportation Institute is examining ways to improve traffic flow along heavily traveled freeways. We need your help with this. This survey should take about 10 minutes to complete.

You are not obligated to answer the questions on this survey, but the information you provide will be very valuable as we work to improve travel. Your survey answers will be confidential and not used in any way to identify you. Please use the next and previous buttons at the bottom of the page.

One randomly selected survey in each city (5 total) will win a $250 MasterCard gift card. To be eligible the survey must be completed and contact information entered in the last question. Your contact information is stored separately and cannot be linked to your responses to these questions. If you have any questions regarding the survey, please contact me at lkaylarsen@gmail.com.

Thank you for your participation.

Sincerely,

Lisa Green
Ph.D. Student, Department of Civil Engineering
Texas A&M University

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, Click Here for more information or you can contact these offices at (979)458-4067 or irb@tamu.edu.

Next >>

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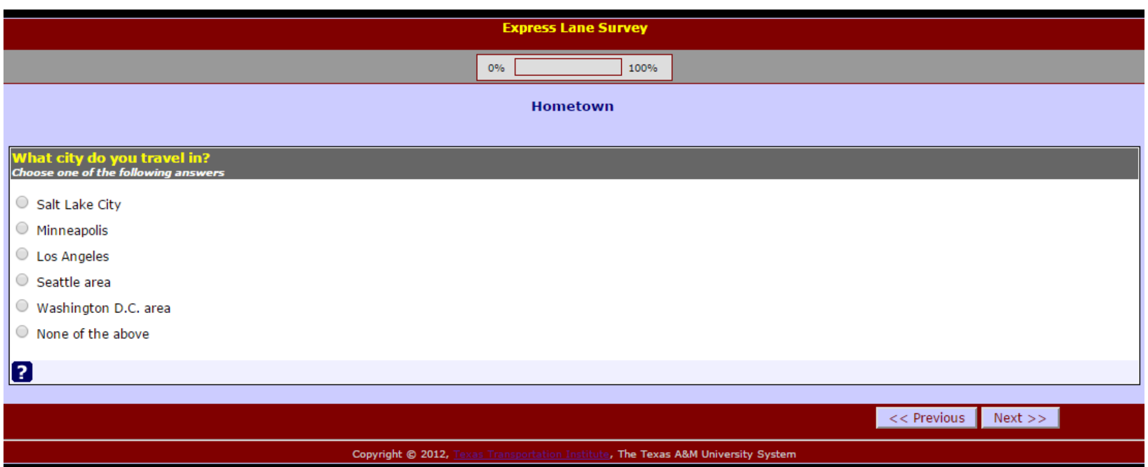

Express Lane Survey

0% 100%

Hometown

What city do you travel in?
Choose one of the following answers

- Salt Lake City
- Minneapolis
- Los Angeles
- Seattle area
- Washington D.C. area
- None of the above

?

<< Previous Next >>

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Express Lane Survey

0% 100%

Hometown

What city do you travel in?
Choose one of the following answers

- ○ Salt Lake City
- ◉ Minneapolis
- ○ Los Angeles
- ○ Seattle area
- ○ Washington D.C. area
- ○ None of the above

?

Which highway do you travel on more often?
Choose one of the following answers

- ○ Interstate 394
- ○ Interstate 35W

?

<< Previous Next >>

Express Lane Survey

0% 100%

Recent Travel

Please tell us about your most recent trip on a Major Freeway traveling towards downtown during the work week (Monday through Friday). A "trip" is any time you traveled on that Freeway.

What was the purpose of your most recent trip?
Choose one of the following answers

- ○ Commuting to or from my place of work (going to or from work)
- ○ Recreational / Social / Shopping / Entertainment / Personal Errands
- ○ Work related (other than between home and work)
- ○ To attend class at school or educational institute
- ○ Other

?

On what day of the week was your most recent trip towards downtown?
Choose one of the following answers

- ○ Sunday
- ○ Monday
- ○ Tuesday
- ○ Wednesday
- ○ Thursday
- ○ Friday
- ○ Saturday

?

What time of day did that trip start? (for example, when did you leave work) ?
Choose one of the following answers

Please choose... ▾

?

What time of day did that trip start? (for example, when did you leave work) ?
Choose one of the following answers

Please choose...

- Please choose...
- 12:00 AM
- 12:30 AM
- 1:00 AM
- 1:30 AM
- 2:00 AM
- 2:30 AM
- 3:00 AM
- 3:30 AM
- 4:00 AM
- 4:30 AM
- 5:00 AM
- 5:15 AM
- 5:30 AM
- 5:45 AM
- 6:00 AM
- 6:15 AM
- 6:30 AM
- 6:45 AM
- 7:00 AM

?

What was the length (in miles) of your trip?
Choose one of the following answers

- ○ Less than 2 miles
- ○ 3 to 5 miles
- ○ 6 to 10 miles
- ○ 11 to 15 miles
- ○ 16 to 20 miles
- ○ 21 to 25 miles
- ○ 26 to 30 miles
- ○ More than 30 miles

?

What time of day did your trip end (for example, when did you arrive at home) ?
Choose one of the following answers

Please choose...

?

What kind of vehicle did you use for your most recent trip?
Choose one of the following answers

- ○ Motorcycle
- ○ Passenger car, SUV, or pick-up truck
- ○ Bus

?

How many people, including you, were in the Passenger Car/ SUV/Pick-up Truck?
Choose one of the following answers

○ 1 ○ 2 ○ 3 ○ 4

○ 5 or more

?

Did you use the Express Lanes for that trip?

- ◉ Yes
- ○ No

?

How much travel time do you think you *saved* compared to the general purpose lanes? (minutes)

[ ] Minutes

Only numbers may be entered in this field

?

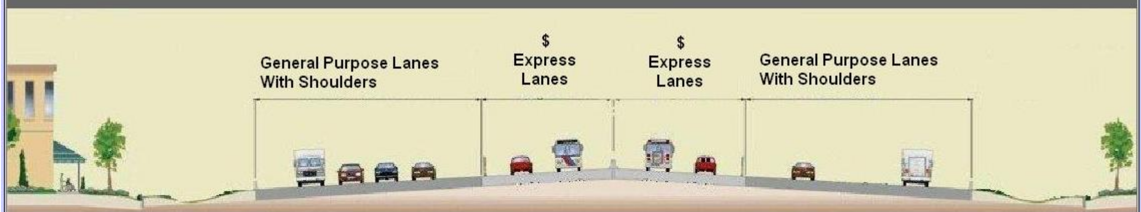
<< Previous Next >>

Express Lane Survey

0% 100%

Express Lanes Description

Express Lanes are a set of lanes within a freeway which are managed continuously to achieve predefined performance objectives. A typical example of an express lane facility is shown in the figure below. During the rush hour the toll is higher and during other times the toll is lower. Drivers often have multiple entrances and exit locations to get on the express lanes. Qualifying high-occupancy vehicles can often travel for free during the peak hours.



Have you ever used the Express Lanes on a Major Freeway?
Choose one of the following answers

- ○ Yes
- ○ No

?

What are the main reasons you used the Express Lanes?
Check any that apply

- ☐ Travel times on Express Lanes are less than those on the general purpose lanes
- ☐ Travel times on the Express Lanes are consistent and predictable
- ☐ My employer pays for the tolls
- ☐ Being able to use the Express Lanes for free as a carpool
- ☐ During the peak hours the Express Lanes will not be congested
- ☐ The Express Lanes are safer / less stressful than driving on the general purpose lanes
- ☐ Trucks and larger vehicles are not allowed on the Express Lanes
- ☐ Other:

?

What are the primary reasons why you have never used the Express Lanes?
Check any that apply

- ☐ I do not want to pay the toll for this trip
- ☐ I don't like that the toll changes based on time of day
- ☐ I have the flexibility to travel at less congested times
- ☐ I can easily use other routes than the Freeway, so I'll just avoid it if I think there is a lot of traffic
- ☐ Express Lane use is complicated or confusing
- ☐ Participation in a carpool is difficult / undesirable
- ☐ Access to the Express Lanes is not convenient for my trips
- ☐ I do not have a credit card so it is inconvenient to set up a toll account
- ☐ The tolls are too high for me
- ☐ I do not feel safe traveling on Express Lanes
- ☐ I do not want a toll transponder in my car
- ☐ The Express Lanes do not offer me enough time savings
- ☐ Other:

?

We want you to now think about all of your trips during the last full week on I-15 in Salt Lake City.
How many *total trips* did you make during the past full work week (Monday to Friday) on I-15 in Salt Lake City? (Each direction of travel is one trip, include trips on the express lanes or general purpose lanes)

Only numbers may be entered in these fields

Trips per week: [ ]

?

How many of those Freeway trips were using the Express Lanes?

Only numbers may be entered in these fields

Trips per week: [ ]

?

How many of those trips would you say you were unusually pressed for time or had a tight schedule ?

Only numbers may be entered in these fields

Urgent Trips Per Week: [ ]

?

<< Previous | Next >>

Express Lane Survey

0% 100%

Read each of the following statements and decide how much you agree with each according to your attitudes, beliefs, and experiences. There is no "right" or "wrong" answer to these questions. People are different, and we are interested in how you feel. Please respond according to the following 9-point scale:

	Strongly disagree 1	Disagree 2	Somewhat disagree 3	Slightly disagree 4	Neither agree nor disagree 5	Slightly agree 6	Somewhat agree 7	Agree 8	Strongly agree 9
It does not matter if I choose the general purpose lane or express lane since it is just luck if the express lane saves me time.	○	○	○	○	○	○	○	○	○
Unless there is no traffic on the freeway, I choose the express lane since traffic could become congested at any time.	○	○	○	○	○	○	○	○	○
If I were listening to the radio and heard there is a major crash on the road I was traveling on, but I was unsure of whether the accident is behind me or ahead of me, I would choose to continue driving on the roadway anyway rather than try a different route.	○	○	○	○	○	○	○	○	○
When buying fuel for my car, I use the most convenient gas station and do not pay much attention to price.	○	○	○	○	○	○	○	○	○
I have often found that what is going to happen will happen.	○	○	○	○	○	○	○	○	○
I usually choose to use the express lane only at the last second, after observing freeway traffic for as long as I can.	○	○	○	○	○	○	○	○	○

Carpooling makes me feel like I am at the mercy of others in the carpool to get to my destination on time.	○	○	○	○	○	○	○	○	○
Whether I am involved in a traffic accident is purely a matter of fate and there is not much I can do to prevent it.	○	○	○	○	○	○	○	○	○
I cannot understand why someone would pay to use the express lanes when the general purpose lanes are available for free, especially when it may or may not save time.	○	○	○	○	○	○	○	○	○
I only choose to use the express lane if the general purpose lanes seem crowded.	○	○	○	○	○	○	○	○	○

?

<< Previous | Next >>

Express Lane Survey

0% 100%

Read each of the following statements and decide how much you agree with each according to your attitudes, beliefs, and experiences. There is no "right" or "wrong" answer to these questions. People are different, and we are interested in how you feel. Please respond according to the following 9-point scale:

	Strongly disagree 1	Disagree 2	Somewhat disagree 3	Slightly disagree 4	Neither agree nor disagree 5	Slightly agree 6	Somewhat agree 7	Agree 8	Strongly agree 9
I rarely complain about traffic problems because that will not help fix the problem.	○	○	○	○	○	○	○	○	○
The coordination involved with carpooling is more hassle than it is worth.	○	○	○	○	○	○	○	○	○
Getting pulled over for speeding is simply a matter of being at the wrong place at the wrong time.	○	○	○	○	○	○	○	○	○
I often look up information about traffic conditions prior to driving anywhere.	○	○	○	○	○	○	○	○	○
The travel choices I make are largely influenced by real-time travel information I obtain from sources like the radio or my GPS.	○	○	○	○	○	○	○	○	○
I tend to make choices about which road to use based on the traffic I encounter.	○	○	○	○	○	○	○	○	○
I would rather stay 30 minutes longer at work than leave during rush hour and face the possibility of being stuck in traffic for an extra 30 minutes.	○	○	○	○	○	○	○	○	○
I listen to the radio while driving so I can get updates on traffic.	○	○	○	○	○	○	○	○	○

I do not like relying on others for rides.	○	○	○	○	○	○	○	○	○
I generally choose to use express lanes only when I feel it is the only way I will make it to my destination on time.	○	○	○	○	○	○	○	○	○
I would choose to use the express lane, knowing there is a 50 percent chance it will not save me time.	○	○	○	○	○	○	○	○	○

?

<< Previous | Next >>

Express Lane Survey

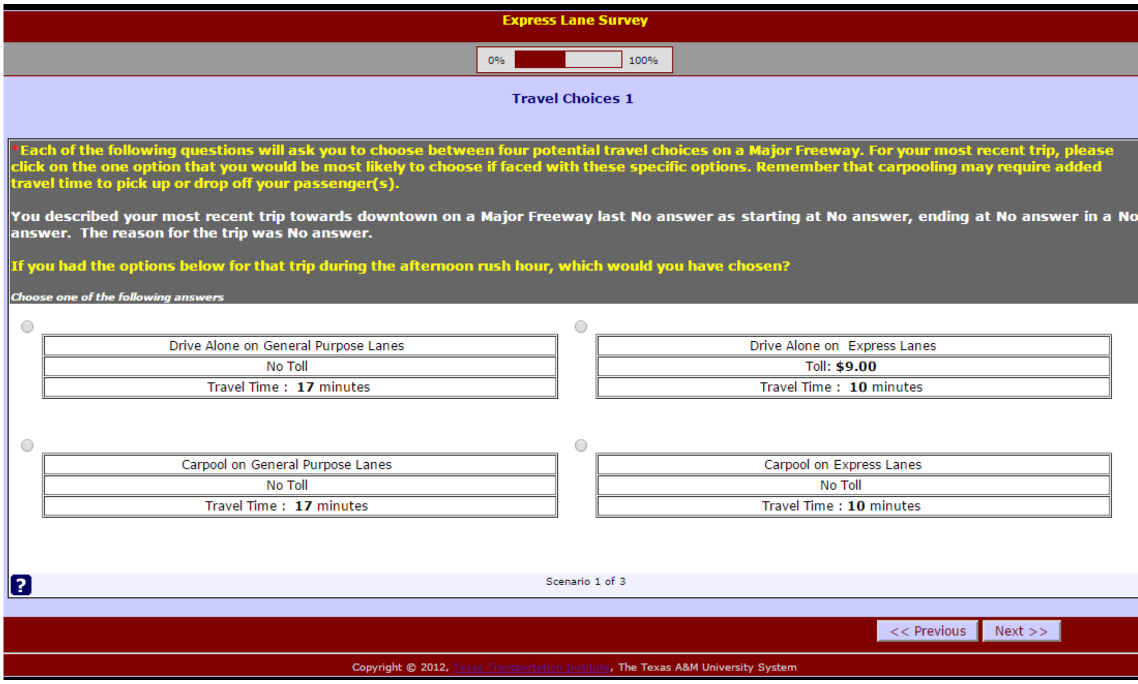
0% 100%

For each of the following statements, please indicate your likelihood of engaging in each activity. Provide a rating from 1 to 9, using the following scale:

	Extremely unlikely 1	Unlikely 2	Somewhat unlikely 3	Slightly unlikely 4	Neither likely nor unlikely 5	Slightly likely 6	Somewhat likely 7	Likely 8	Extremely likely 9
I would invest 10% of my annual income in a quality/blue-chip stock.	○	○	○	○	○	○	○	○	○
I would lend a friend the money needed to purchase a $45 toll tag so they could use the express lane.	○	○	○	○	○	○	○	○	○
I would lend a friend an amount of money equivalent to one month’s income.	○	○	○	○	○	○	○	○	○
I would bet a day’s income at the horse races.	○	○	○	○	○	○	○	○	○

? **Please note that after clicking Next, you will not be able to go back. Make sure your responses on this and previous pages are final before proceeding.**

<< Previous | Next >>



Express Lane Survey

0% 100%

Travel Choices 1

*Each of the following questions will ask you to choose between four potential travel choices on a Major Freeway. For your most recent trip, please click on the one option that you would be most likely to choose if faced with these specific options. Remember that carpooling may require added travel time to pick up or drop off your passenger(s).

You described your most recent trip towards downtown on a Major Freeway last No answer as starting at No answer, ending at No answer in a No answer. The reason for the trip was No answer.

If you had the options below for that trip during the afternoon rush hour, which would you have chosen?

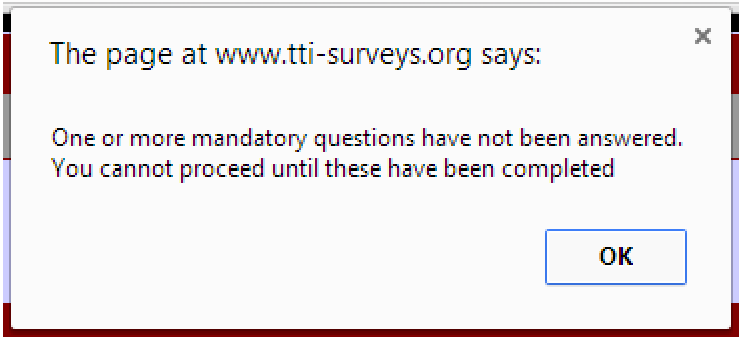
Choose one of the following answers

Drive Alone on General Purpose Lanes	Drive Alone on Express Lanes
No Toll	Toll: **$9.00**
Travel Time : **17** minutes	Travel Time : **10** minutes

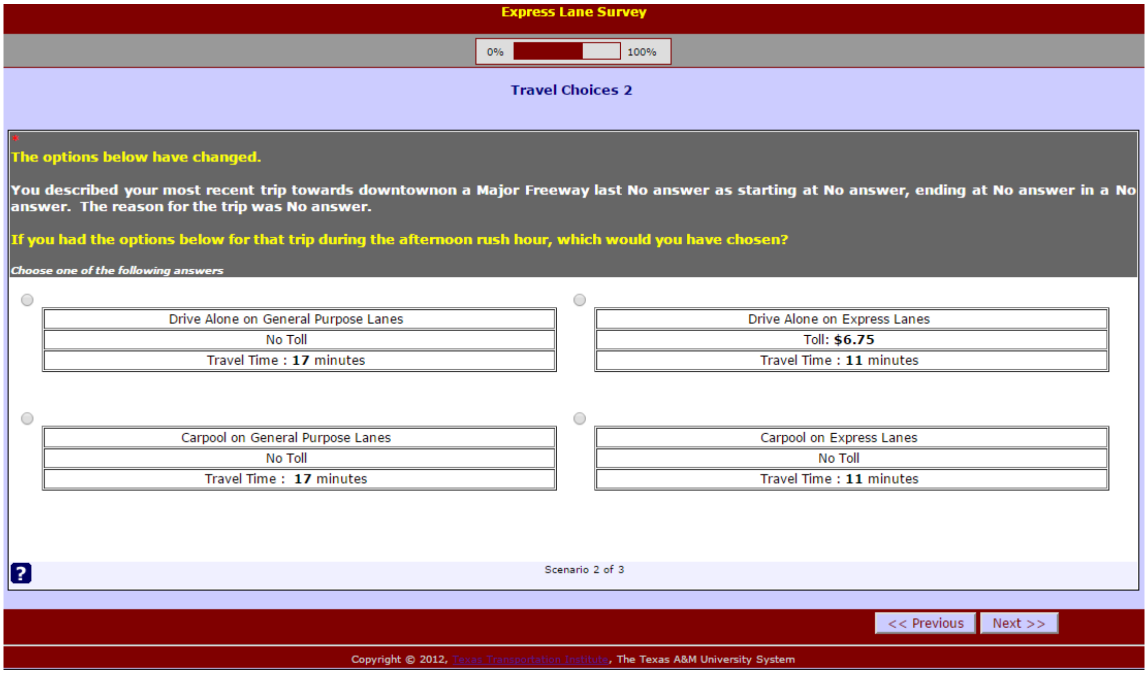
Carpool on General Purpose Lanes	Carpool on Express Lanes
No Toll	No Toll
Travel Time : **17** minutes	Travel Time : **10** minutes

Scenario 1 of 3

<< Previous Next >>



The page at www.tti-surveys.org says:
One or more mandatory questions have not been answered.
You cannot proceed until these have been completed
OK



Express Lane Survey
0%
100%
Travel Choices 2
The options below have changed.
You described your most recent trip towards downtownon a Major Freeway last No answer as starting at No answer, ending at No answer in a No answer. The reason for the trip was No answer.
If you had the options below for that trip during the afternoon rush hour, which would you have chosen?
Choose one of the following answers
Drive Alone on General Purpose Lanes
No Toll
Travel Time : 17 minutes
Drive Alone on Express Lanes
Toll: $6.75
Travel Time : 11 minutes
Carpool on General Purpose Lanes
No Toll
Travel Time : 17 minutes
Carpool on Express Lanes
No Toll
Travel Time : 11 minutes
Scenario 2 of 3
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Next >>
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Express Lane Survey

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Travel Choices 3

*

The options below have changed.

You described your most recent trip towards downtown on a Major Freeway last No answer as starting at No answer, ending at No answer in a No answer. The reason for the trip was No answer.

If you had the options below for that trip during the afternoon rush hour, which would you have chosen?

Choose one of the following answers

○ Drive Alone on General Purpose Lanes
No Toll
Travel Time : **17** minutes

○ Drive Alone on Express Lanes
Toll: **$6.75**
Travel Time : **9** minutes

○ Carpool on General Purpose Lanes
No Toll
Travel Time : **17** minutes

◉ Carpool on Express Lanes
No Toll
Travel Time : **9** minutes

?

Scenario 3 of 3

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Express Lane Survey

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Demographics

The following questions will be used for statistical purposes only and answers will remain confidential. All of your answers are very important to us and in no way will they be used to identify you or released to any other person outside the research team.

What is your age?

Choose one of the following answers

○ 16 to 24 ○ 25 to 34 ○ 35 to 44 ○ 45 to 54 ○ 55 to 64 ○ 65 and over

?

What is your gender?

Choose one of the following answers

○ Male ○ Female

Please describe the type of household you live in.

Choose one of the following answers

○ Single adult ○ Married without children ○ single parent family

○ Unrelated adults ○ Married with child(ren) ○ Other

Including yourself, how many people live in your household?

Only numbers may be entered in this field

All together, how many motor vehicles (including cars, vans, trucks, and motorcycles) are available for use by members of your household?

Only numbers may be entered in this field

What category best describes your occupational or work status?
Choose one of the following answers

○ Professional / Managerial	○ Administrative / Clerical	○ Stay-at-home homemaker / parent	○ Self employed
○ Manufacturing	○ Sales	○ Student	○ Educator
○ Technical	○ Retired	○ Unemployed / seeking work	○ Other

What was the last year of school that you have completed?
Choose one of the following answers

○ Less than high school	○ Some college or vocational school	○ Postgraduate degree
○ High school graduate	○ College graduate	

What was your gross annual household income before taxes in 2013?
Choose one of the following answers

○ Less than $10,000	○ $35,000 to $49,999	○ $200,000 or more
○ $10,000 to $14,999	○ $50,000 to $74,999	◉ Its easier to tell my hourly wage rate
○ $15,000 to $24,999	○ $75,000 to $99,999	
○ $25,000 to $34,999	○ $100,000 to $199,999	

?

Hourly wage rate ($/hour)

Only numbers may be entered in this field

Thank you for taking the time to fill in this survey. Your responses will be helpful as we work to improve travel in your area. If you have any general comments about travel on I-394 in Minneapolis, please type them below.

Please finish the survey by hitting "Submit" below. You will then have a chance to enter your contact information to be eligible to win one of the $250 MasterCard gift cards. Your contact information is stored separately and cannot be linked to your responses to these questions.

The survey results will be made available at www.TravelSurveys.org/SurveyResults.html. Thanks!

?

<< Previous | Submit

Texas A&M Transportation Institute

Contact Information

Thanks! We appreciate the time you took to fill in this survey. The next page will ask for contact information so that you can be entered into a drawing for five, $250 MasterCard gift cards. The rules of the contest are below:

1. Contest is void where prohibited by law. No purchase necessary to win, but the survey must be fully completed by September 15, 2014. Late or duplicate entries will not be accepted.

2. All contestants must be 18 or older.

3. Five winners will be chosen, one from each city. Each prize is a MasterCard gift card worth $250. The winner will be selected on September 30, 2014 at CE/TTI tower on the campus of Texas A & M campus. Winner need not be present.

4. The winner is responsible for all applicable federal, state and local taxes including income tax.

5. Employees of the Texas A&M Transportation Institute, the Utah Department of Transportation, the Minnesota Department of Transportation, the California Department of Transportation, the Washington State Department of Transportation, Transurban, State Road and Tollway Authority and members of their families are not eligible to enter to win.

6. Contest is void where prohibited by law.

Next >>

Contact Information

0% 100%

Contact Information

What city do you travel in?

Choose one of the following answers

- Salt Lake City
- Minneapolis
- Los Angeles
- Seattle area
- Washington D.C. area
- None of the above

?

Please enter your name

Please enter your email address or phone number

?

Submit

Thank you!
Your responses are saved, you may now close the window.

APPENDIX E

LOCATIONS SURVEY ADVERTISED

	Facebook	Twitter	Electronic Newsletter/Email
Seattle	https://www.facebook.com/pages/WashingDoton-State-Department-of-Transportation	https://twitter.com/wsdot; http://twitter.com/GoodToGoWSDOT	-
SLC	-	https://twitter.com/UtahDOT	E-newsletter. Sent to approximately 13,000 accounts.
LA	https://www.facebook.com/pages/City-of-Los-Angeles-Department-of-Transportation/114582841932552; https://www.facebook.com/expresslanes	https://twitter.com/CaltransDist7	-
DC	-	https://twitter.com/DDOTDC	E-newsletter. Sent to approximately 7,500 individuals.
Minn	https://www.facebook.com/mndot	https://twitter.com/mndottraffic	E-newsletter. Sent to existing MnPASS Express Lane account holders (about 25,150 email addresses).

APPENDIX F

EXAMPLE MODEL CODE

```
?Model 8

sample;all$

create; if (AGE=1|AGE=2) LOWAGE=1; (else) LOWAGE=0$
create; if (AGE=3|AGE=4) MIDAGE=1; (else) MIDAGE=0$
create; if (AGE=5|AGE=6) HIGHAGE=1; (else) HIGHAGE=0$

create; if (GENDER=1) MALE=1; (else) MALE=0$

create; if (HHTYPE=1) SGLADT=1; (else) SGLADT=0$
create; if (HHTYPE=2) UNRELA=1; (else) UNRELA=0$
create; if (HHTYPE=3) MARWOC=1; (else) MARWOC=0$
create; if (HHTYPE=4) MARWC=1; (else) MARWC=0$
create; if (HHTYPE=5) SGLPAR=1; (else) SGLPAR=0$

create; if (CHILDAGE=1) HHYOUNGC=1; (else) HHYOUNGC=0$

create; if (OCC=1) OCPROMN=1; (else) OCPROMN=0$
create; if (OCC=2) OCTECH=1; (else) OCTECH=0$
create; if (OCC=3) OCSALES=1; (else) OCSALES=0$
create; if (OCC=4) OCADMIN=1; (else) OCADMIN=0$
create; if (OCC=5) OCMANUF=1; (else) OCMANUF=0$
create; if (OCC=6) OCHOME=1; (else) OCHOME=0$
create; if (OCC=7) OCSTUD=1; (else) OCSTUD=0$
create; if (OCC=8) OCSELF=1; (else) OCSELF=0$
create; if (OCC=9) OCUNEMP=1; (else) OCUNEMP=0$
create; if (OCC=10) OCRET=1; (else) OCRET=0$
create; if (OCC=11) OCEDUC=1; (else) OCEDUC=0$

create; if (EDUC=1|EDUC=2) LOWEDUC=1; (else) LOWEDUC=0$
create; if (EDUC=3|EDUC=4) MIDEDUC=1; (else) MIDEDUC=0$
create; if (EDUC=5) HIGHEDUC=1; (else) HIGHEDUC=0$

create; if (HHINC=1|HHINC=2|HHINC=3) LOWINC=1; (else) LOWINC=0$
create; if (HHINC=4|HHINC=5) LMIDINC=1; (else) LMIDINC=0$
```

```
create; if (HHINC=6|HHINC=7) HMIDINC=1; (else) HMIDINC=0$
create; if (HHINC=8|HHINC=9) HINC=1; (else) HINC=0$

create; if (TRPPURP=1) TPCOMM=1; (else) TPCOMM=0$
create; if (TRPPURP=2) TPREC=1; (else) TPREC=0$
create; if (TRPPURP=3) TPSCH=1; (else) TPSCH=0$
create; if (TRPPURP=4) TPWRKREL=1; (else) TPWRKREL=0$

create; if (DAYWEEK=2|DAYWEEK=3|DAYWEEK=4|DAYWEEK=5|DAYWEEK=6)
WEEKDAY=1; (else) WEEKDAY=0$

create; if (LENGTH=1|LENGTH=2|LENGTH=3) SHORTTRP=1; (else)
SHORTTRP=0$
create; if (LENGTH=4|LENGTH=5) MIDTRP=1; (else) MIDTRP=0$
create; if (LENGTH=6|LENGTH=7|LENGTH=8) LONGTRP=1; (else) LONGTRP=0$


RPLOGIT     ;Lhs=DECISION,NALTS,MODE;
            Choices = A,B,C,D;
            Halton;
            Maxit=500; pts=500;pds=3;
            Fcn=c_time(t),A_B[n],A_C[n],A_D[n];

            Model:U(A)=0+c_time*TTIME+c_toll*TOLL/

        U(B)=A_B+c_time*TTIME+c_toll*TOLL+cb_vehocc*VEHOCC+cb_psy12*PS
Y12/
                U(C)=A_C+c_time*TTIME+c_toll*TOLL+cc_male*MALE

        +cc_psy2*PSY2+cc_psy4*PSY4+cc_psy9*PSY9+cc_psy10*PSY10/

        U(D)=A_D+c_time*TTIME+c_toll*TOLL+cd_vehocc*VEHOCC+cd_lowage*L
OWAGE+cd_psy4*PSY4+cd_psy12*PSY12+cd_psy19*PSY19;
                check data;


crosstab$
calc;list;VTTS=(b(1)/b(5))*60 $
```