ROLE OF CHILDHOOD CONTEXT AND EXPERIENCE IN SHAPING ACTIVITY-TRAVEL CHOICES IN ADULTHOOD

Kamryn Long
The University of Texas at Austin
Department of Civil, Architectural and Environmental Engineering
301 E. Dean Keeton St. Stop C1761, Austin TX 78712
Tel: 512-471-4535; Email: kamrynlong@utexas.edu

Denise Capasso da Silva
Arizona State University, School of Sustainable Engineering and the Built Environment
660 S. College Avenue, Tempe, AZ 85287-3005
Tel: 480-727-3613; Email: dcapass1@asu.edu

Felipe F. Dias
The University of Texas at Austin
Department of Civil, Architectural and Environmental Engineering
301 E. Dean Keeton St. Stop C1761, Austin TX 78712
Tel: 512-471-4535; Email: fdias@utexas.edu

Sara Khoeini
Arizona State University, School of Sustainable Engineering and the Built Environment
660 S. College Avenue, Tempe, AZ 85287-3005
Tel: 480-965-3589; Email: skhoeini@asu.edu

Aarti C. Bhat
The University of Texas at Austin
College of Natural Sciences and Liberal Arts
4229 Sandorna View, Leander TX 78641
Tel: 512-771-3521; Email: aarti.bhat96@gmail.com

Ram M. Pendyala
Arizona State University, School of Sustainable Engineering and the Built Environment
660 S. College Avenue, Tempe, AZ 85287-3005
Tel: 480-727-4587; Email: ram.pendyala@asu.edu

Chandra R. Bhat (corresponding author)
The University of Texas at Austin
Department of Civil, Architectural and Environmental Engineering
301 E. Dean Keeton St. Stop C1761, Austin TX 78712
Tel: 512-471-4535; Email: bhat@mail.utexas.edu
and
The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

ABSTRACT

To what extent do experiences in childhood and parental influences shape mobility choices and behaviors in adulthood? This is the central question that this research seeks to answer through an analysis of a unique survey data set that includes variables describing a number of contextual factors from the individual's childhood. The study presents a joint model of vehicle ownership and transit usage in adulthood as a function of childhood influences and experiences, while controlling for other socio-economic and demographic variables.

Keywords: vehicle ownership, transit use, childhood influences, traveler behavior, attitudes and perceptions

1. INTRODUCTION

This study aims to investigate the significance and size of the effect of childhood experiences and parental influences on activity-travel choices in adulthood. The lack of rich data about childhood experiences and parental influence in traditional travel survey data sets has limited the ability to explore the role of these factors in the field of travel behavior. However, there is increasing realization that a good understanding of childhood experience and parental influence effects on future adult travel behavior can be used to inform intervention policies during childhood that may lead to what is generally considered to be societally-desirable travel behavior (such as lower vehicle ownership levels and less solo car use in adulthood) (*1*).

The realization of the need for research on the role of childhood experiences and parental influences on behaviors and choices in adulthood has translated to a growing, even if still relatively limited, body of literature. Thigpen and Handy (*2*), for example, explore the effects of building a stock of bicycling experience in youth. They note that bicycling behavior (experience) in childhood shapes attitudes toward bicycling. Similarly, Bou-Mjahed and Mahmassani (*3*) find that increased technology engagement leads to lesser car-dependence in adulthood and more openness to technological transportation innovations. In the broader human development field, these permeations of childhood experiences into adulthood behavior is considered to be through identity theory, where habitual behavior continually gets reinforced over time and becomes lodged as a self-identity that helps individuals preserve their place in society (*4*). While the above travel-related studies focus on direct childhood experiences, there is little literature on parental perspectives and actions (during childhood) on behaviors manifested when the child grows into adulthood. There is, however, considerable literature devoted to the role of parental influences in shaping the behavior during childhood itself. For example, children's mode to school is often a parental decision, and it is the parent's perception of safety and support for the use of active modes of transportation that significantly affects the probability that children will use active modes of transportation to travel to and from school (*5, 6, 7*). While these studies speak to the influence that parents have on choices during childhood (including youthhood or teenage years), they do not shed light on how those influences shape the travel choices later in adulthood. Overall, research on childhood effects on current adulthood activity-travel behavior have been narrowly confined to a few studies of direct childhood experiences, with little to no travel-related literature on parental influences during childhood on adulthood behavior. On the other hand, human development literature theories suggest that, in addition to actual direct childhood experiences, parental influences do get internalized and taken into adulthood. For example, values-socialization theory suggests that parents' values and practices do get transmitted to, and internalized by, children, and that these values can permeate into adulthood (*8*).

Of course, in addition to the lack of data on childhood effects in traditional surveys, the challenge associated with understanding the aforementioned effects of childhood experiences (both direct and through parental influence) on adulthood activity-travel choices is that there are a number of confounding factors contributing to endogeneity in the relationships. Socio-economic and demographic characteristics, built environment attributes (such as modal accessibility and urban design features), the technological landscape, and attitudes after all shape behaviors at any point in time. While it is a complex undertaking to disentangle the "true" childhood experience effects from these other effects (many of which change over time), there is a need to control, to the extent possible, the effects of these other factors when studying childhood experience effects. One direction is to take a life course approach to travel behavior analysis and exploration. The life course approach to studying individual life trajectories appears to have largely emerged in the

1960s, with a view to providing a broad framework to consider how temporal, social and historical contexts affect behavior (*9*). The application of such an approach to transport behaviors is a more recent phenomenon, and considerable progress has undoubtedly been made in studying mobility behaviors in the context of changes in socio-economic and demographic characteristics, resulting in research studies that have strived to construct mobility biographies to better understand travel behavior and residential choices over the life course (*10*). These studies have generally shown strong evidence of a linkage between life cycle events and changes in activity-travel choices, vehicle acquisition or disposal, and residential location (e.g., *11*, *12*). But a problem with such a life course approach is that it requires detailed longitudinal history data over time. Besides, many of the studies implementing the life course approach have rarely considered the relationship between childhood experiences on the one hand and activity-travel choices in adulthood on the other.

In the above context, this study attempts to contribute to the literature in multiple ways. First, from a data standpoint, it uses a unique cross-sectional 2014 Who's On Board Mobility Attitudes Survey or WOBMAS (*13*), which includes detailed attitudinal and behavioral information for a sample of respondents residing in 46 metropolitan areas in the United States. The survey data set includes a rich set of variables that describe current mode usage patterns and levels, trip frequencies, socioeconomic attributes and vehicle ownership and usage. What is unique about this survey, however, is that it includes a battery of questions on prior childhood experiences (both direct and parental influences) of the adult individual. And unlike some earlier similar survey-based studies examining childhood experience effects on adulthood activity-travel behavior, the current study uses a large sample of 12,000 respondents, which may aid in better controlling for demographic, lifecycle, and built environment effects when capturing "true" childhood experience effects. Second, and related to the first, the large sample size allows us to consider interaction effects among current demographic characteristics, as well as any moderating effects of childhood experiences through typically unchanging (over the life of an individual) demographic characteristics (such as race and gender) as well as potentially changing (over the life of an individual) lifecycle characteristics (such as presence of a child and income earnings). Further, our study, because it obtains information from individuals from multiple generations, also is able to capture any cohort effects. That is, in addition to inter-individual variations in adulthood activity-travel behavior due to adulthood demographics, the study allows the capture of intrinsic cohort effects related to inter-generational variations in culture when young (including how information is acquired, filtered, and retained through social transmission; see, for example, Richerson and Boyd (*14*)) that may lead to differential child experience effects (across cohorts) on adult activity-travel behavior. For example, the increasing tendency in recent years toward "helicopter parenting" (or "overprotective parenting") may imply that parental influence in the younger generations may have a stronger retention intensity and influence on, adulthood activity-travel choices than perhaps parental influence in the older generations.[1] Third, we study the impacts of childhood experiences on adulthood vehicle ownership and transit use behavior. Earlier studies,

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[1] The one caveat here is that, because different generations have different numbers of years between their childhood and current adult life, these "cohort effects" cannot be disentangled with a pure "distance from childhood" effect. That is, as individuals live longer away from their parents, they interact with many others, leading to a fading of parental influence as individuals age. This would also be consistent with social norms associated with child development, where, as time passes by, adult children attempt to develop their own self-identity in ways that differentiate them from their parents (*15*).

such as Thigpen and Handy (*2*, *16*) and Bou-Mjahed and Mahmassani (*3*), focus on other activity-travel behaviors (adulthood bicycling behavior or youth's driver's licensing delay in the Thigpen and Handy studies, and adulthood technology use and interest in autonomous vehicles in the Bou-Mjahed and Mahmassani (*3*) study). As studies continue to explore different dimensions of activity-travel behavior, they contribute to the pool of knowledge related to childhood experiences on overall adulthood activity-travel behavior. The vehicle ownership and transit use variables are of much interest and used extensively in the travel behavior arena to describe mobility choices and styles, and are therefore chosen as the dependent variables of interest in this study as well. Fourth, the study uses a relatively extensive set of childhood experience variables (nine in all), as opposed to less than one handful in many earlier studies, and explicitly includes not only direct childhood experience variables, but also parental influence effects. Empirically, then, the current paper combines aspects of self-identity theory (the pathway for permeation of direct childhood experiences into adulthood behavior) and social interaction theory (the pathway for permeation of parental influence in childhood on adult behavior). Fifth, as indicated by Thigpen and Handy (*16*), much of the earlier studies of childhood experience effects on future activity-travel behavior have been based on bivariate statistical analysis. In the current study, we use a bivariate ordered-response modeling approach to model the effect of childhood experience (and other factors) on the count of household vehicle ownership (0, 1, 2, or 3+ cars in the household) and transit use (never used, <2 times a month, and ≥2 times a month). The joint modeling of vehicle ownership and transit use acknowledges the possible presence of common unobserved factors that impact the two choices. For instance, individuals in households that are not auto-oriented are likely to own fewer vehicles and also use transit more. If that is the case, then it implies that the choices of vehicle ownership and transit use are being made jointly as a bundle. Ignoring this dependence and estimating separate models is inefficient in estimating covariate effects for each outcome because it fails to borrow information on the other outcome, and is limited in its ability to answer intrinsically multivariate questions such as the effect of a covariate on a multidimensional outcome (*17*). But, perhaps most importantly, if one of the dependent outcomes is used to explain the other dependent outcome (such as examining the effect of vehicle ownership on transit use propensity), and if the outcomes are not modeled jointly to recognize the presence of unobserved exogenous variable effects, the result is the inconsistent estimation of all variables (including the effects of childhood experience-related variables, other variables, and the first dependent outcome) on the second outcome variable (*18*; *19*, page 80). Finally, unlike all other studies we are aware of (both in travel behavior literature and the broader human development literature), we explicitly characterize the size effect of the childhood experience variables (differentiated by direct versus parental influence effects). This is a key issue that, surprisingly, has not received the attention it deserves. If it is indeed true that childhood experiences affect choices and behaviors in adulthood in a sizeable way (at least for specific segments of the population, if not the entire population), then it suggests the design of targeted interventions, campaigns, and strategies that would provide the childhood experiences and context necessary to bring about sustainable mobility behaviors later in life. Further, by disaggregating the size of childhood experience effects into direct experience and parental influence effects, the study can provide insights on whether to have policies that engender childhood experiences directly (possibly through school programs and activities) or by targeting parents.

    As with every research effort, this effort is not without its own limitations. While we accommodate cohort effects, and the potential moderation of childhood experience effects based on cohort, our representation of the current built environment is rather simple. Specifically, the

built environment is represented based on the reported residential neighborhood type of the respondent: urban, suburban, small town, or rural. Moreover, there was no specification provided to respondents on how to characterize their residential neighborhood. Respondents had to subjectively characterize their neighborhood, which could introduce perception bias. Further, because of the specialized and purely online nature of the WOBMAS platform to collect information from youth/adults (ages 16 or older), the survey sample is not representative of the US population of youth/adults (on a positive note, the online administration method makes it possible to obtain information in a straightforward manner from a large set of respondents residing in multiple metropolitan areas in the country, all in a very cost-effective manner). Due to the purely online nature of the survey, the general descriptive statistics of vehicle ownership and transit use cannot be generalized to the U.S. population. But the effects of the exogenous variables impacting the dependent variables, as embodied in the relational model results of this paper, should be relatively unimpacted by sample unrepresentativeness. Besides, as an exploratory study, the paper still provides important insights on the relationships of the exogenous variables (including childhood experience effects) on adulthood vehicle ownership and transit use choices. Finally, the survey used a retrospective recall method to obtain information on childhood experiences (including direct experiences and parental influences). It is entirely possible that the recall, especially of the experience many years back in childhood, is inaccurate, either because of true memory loss or because of current demographics/behaviors somehow contaminating the recall of childhood experiences. This last possibility implies that current demographics/behaviors can become endogenous to childhood experience recollections, posing problems in econometric estimation. A way out of this situation may be to use longitudinal histories that include childhood experiences and current behaviors in future research. In the rest of this paper, we will not revisit or caveat our results repeatedly based on the limitations discussed above, but our results should be viewed and absorbed with these limitations in mind

The remainder of this paper is organized as follows. The next section presents an overview of the data, while the third section presents the modeling methodology. The fourth section discusses the model estimation results. Conclusions and implications are presented in the final section.

2. DATA DESCRIPTION

To meet the objectives of this study, it was necessary to identify a data set that included a reasonably rich set of data about childhood experiences. A data set that includes this information is the 2014 WOBMAS. This online survey includes detailed attitudinal and behavioral data from a sample of respondents residing in 46 metropolitan areas in the U.S. A novel stratified sampling scheme was adopted as part of the survey design to obtain survey responses from individuals residing in different geographic areas with differing levels of transit service.

To conserve on space, we relegate a summary description of the sample used in our analysis (N=10,404 after some cleaning and processing of the original data) to an online supplement to this paper, available at http://www.caee.utexas.edu/prof/bhat/ABSTRACTS/Childhood/OnlineSupplement.pdf. Eight childhood experience variables were available in the sample. Except for the child residential location type variable (which was collected as a response to residential neighborhood in one of the urban, suburban, small town, and rural categories), the original responses to the other childhood experience questions were collected on a five-point Likert scale, from strongly disagree to strongly agree. For our empirical analysis, we converted these ordinal responses to binary variables by

combining the "strongly agree" and "agree" responses into a single "agree" category, and combining the remaining three categories into a single disagree category (=strongly disagree + disagree + neutral). Additionally, childhood experience variables were disaggregated further into "direct" vs "parent influence" experiences to differentiate the impacts of direct childhood experiences from parental influences that may have shaped perceptions. In general, the sample depicts socio-economic and demographic characteristics that would render it suitable for the type of analysis undertaken in this study. In terms of the two dependent variables, the household vehicle ownership distribution (N=10,404) is as expected, with only 3.3% of households having no cars, 30.0% owning one car, 44.5% owning two cars, and 22.2% owning three or more cars. The transit use frequency variable represents the distribution of individuals among those who reported that transit was available as an option to them (8,555 of the 10,404 respondents reported transit as an available option). This distribution is as follows: never used transit – 52.2%, infrequent use of transit (<2 times a month) – 26.2%, and frequent use of transit (≥2 times a month) – 21.6%.[2]

A more detailed examination of direct and parent childhood variables in relation to the dependent variables of interest is provided in Table 1. The second main column of the table shows the distribution of vehicle ownership levels by agreement or disagreement on the childhood experience questions. In general, the vehicle ownership distribution does not seem to vary substantially based on the response to the childhood experience questions. This is not surprising, given that the childhood experience statements are more related to transit use and residential neighborhood type rather than vehicle ownership and use per se. Nevertheless, there is a pattern of correlation implying that childhood experiences related to transit and residential neighborhood type can help shape vehicle ownership in later years. For example, consider the statement indicating whether an individual traveled alone on public transit as a child. While 18.5 percent of those who agree reside in households with three or more vehicles, 24.4 percent of those who disagree reside in such high car ownership households. Similar patterns are seen for the other statements as well, although the effects of the childhood experience variables on household vehicle ownership are not as clear-cut as those in the third main column of Table 1 pertaining to the effects of childhood experience variables on transit user levels (for ease in presentation in Table 1, we group the two transit user frequency levels of "infrequent, <2 times a month" and "frequent, ≥2 times a month into a single "Transit User" category). In particular, the statistics in this third main column show that childhood experiences play a significant role in shaping transit use choices in adulthood. For example, 55 percent of those who agree with the statement that they traveled alone on public transit as a child indicate that they currently use public transit. However, only 43.3 percent of those who disagree with that statement indicate that they currently use transit.

3. MODELING METHODOLOGY
Due to space considerations, the details of the model estimation approach and size effects calculation are provided in the online supplement. In this study, there are two ordinal dependent

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[2] The table in the online supplement also provides a comparison of the sample distribution with that of the U.S. population of individuals over 16 years of age (because the respondents in our survey are individuals and not households, the online supplement only compares individual characteristics between our sample and the U.S. population). Generally speaking, our sample (relative to the U.S. population) over represents Baby Boomers and under-represents the Silent Generation, is much more non-Hispanic white, has a slightly higher share of women than men, and shows a higher share of unemployed individuals. But, as indicated earlier, all segments of the population are represented in adequate numbers in our sample, and thus relational results in this paper should be relatively unimpacted by the unrepresentativeness.

variables - the motorized vehicle ownership level of the respondent's household and the respondent's transit use frequency. Thus, the model system in the current paper takes the form of a bivariate ordered-response system for individuals who have transit available to them. However, for individuals who do not have transit available, the model collapses to a univariate ordered-response system.

Once the joint model is estimated, the results can be used to quantify the relative contributions of each set of observed factors in explaining vehicle ownership and frequency of transit use (along with the remaining unexplained portion). The four factors are: (1) demographic variables (DEM), (2) transportation-related variables (TRAN), (3) direct childhood experience variables (DIRECT), and (4) parent influence variables (PARENT). In the final model specification, almost all the interaction variable effects consisted of only demographic variable interactions, and so they are conveniently grouped with the DEM variables and not included separately. This process also enables the estimation of size percentages for different segments of the same (such as Millennials versus non-Millennials) by focusing only on the respondents in each segment. Doing so also recognizes the limited interactions we found between the PARENT variables and the DEM variables characterizing the generational divide.

4. RESULTS
This section presents an overview of the study results. The model estimation results are presented first, while the estimation of the size effects is presented second.

4.1 Model Estimation Results
The joint model of vehicle ownership and transit use frequency is presented in Table 2. The coefficients represent the significant (at the 5% level) effects of variables on the underlying vehicle ownership propensity and transit use propensity (a non-entry corresponding to a row variable in a column indicates that the effect of the corresponding variable is not statistically significant for the dependent variable dimension represented by that column). The observed vehicle ownership values are in four categories (0, 1, 2, and 3+), while transit use frequency is observed in three categories when available (never, less than twice per week, twice or more per week). As expected, many demographic variables significantly influence vehicle ownership and transit use propensities.

In the group of <u>unchanging demographic</u> characteristics, minority groups have a decreased propensity to own cars, and a higher propensity to use transit, compared to the "White" race category. Interestingly, this was the only unchanging (over the course of an individual's life) variable that impacts both vehicle ownership and transit use. In particular, we did not find any statistically significant (or even marginally significant) effect of gender on transit use. Further, as discussed in the introduction section, we also considered moderating effects of the childhood experience variables (discussed later) through race and gender interactions with the childhood experience variables (to test if childhood experiences get dampened or heightened for specific race and/or gender groups). But none of these interaction effects came out to be even marginally significant, suggesting that, at least in the context of adulthood vehicle ownership and transit use choices, race and gender do not play a role in the effects pathway of childhood experience effects.

Many other potentially <u>changing (over the course of an individual's life) demographic</u> variables turned out to be important in explaining adulthood travel choices. Higher income is associated with a higher propensity of vehicle ownership; interestingly, higher income levels are associated with a higher propensity of transit use as well. This latter finding is consistent with the

notion that, if high income individuals locate themselves such that transit is available, it is because they intend to use it and do end up using it at a higher level of frequency (such as in transit rich cities including New York, Boston, Chicago, and Washington D.C.). Compared to the Baby Boomer generation, individuals in all other generations display a lower propensity of vehicle ownership and a higher propensity of transit use (except for the Silent Generation). These findings are along expected lines and consistent with recent evidence that younger cohorts are depicting lower levels of auto ownership and higher levels of transit use compared to prior generations (e.g. *20, 21, 22*). In addition to these direct generational effects, we also examined possible variations across generations in the effects of the childhood experience variables (through interactions of the childhood experience variables with the generational variables). These are discussed later under the childhood experience variable effects.

Other demographic variables also provide indications that are consistent with expectations. Presence of children is associated with a higher propensity of vehicle ownership and a lower propensity of transit use; the presence of multiple workers is also associated with a higher propensity of vehicle ownership, but a higher propensity of transit use. Employed individuals exhibit a propensity to use transit more frequently. These findings suggest that transit plays an important role in serving commuters. The number of licensed drivers is a strong determinant of vehicle ownership propensity, while the possession of a driver's license by an individual reduces transit use propensity. We also introduced household size as a variable in the model, but this did not have a statistically significant effect on vehicle ownership or transit use after including the number of licenses variable. A number of interaction terms are significant, indicating that the effects of presence of children and income vary by cohort. Low income Millennials depict a higher vehicle ownership propensity; while this may appear counter-intuitive at first, this finding arises because lower income Millennials are still residing with their parents or guardians and these households generally tend to have higher levels of vehicle ownership. Similarly, many low income Silent Generation individuals are also residing with children (who take care of the elderly parents) and these households tend to have more vehicles than households in which Silent Generation individuals may be living independently.

In the context of the <u>transportation</u> variables, as expected, those in urban locations tend to have a lower propensity to own vehicles and a higher transit use propensity, while those in smaller towns and rural areas tend to have a higher propensity to own vehicles and a lower transit use propensity (compared to individuals in suburban locations). Vehicle ownership is negatively associated with transit use propensity, as expected.

The <u>childhood experience</u> effects are disaggregated in the table into direct experience effects and parental influence effects. In accommodating these effects, a whole host of interaction effects were considered, to capture possible heterogeneity across different demographic groups (defined by both unchanging as well as changing characteristics). These included interactions of the child experience variables with gender, income, race, and the generation variables. Almost all of these did not turn out to be statistically significant, except for selected interactions of the parent influence variables with the generation variables. Overall, the result suggests little to no differences in the childhood experiences based on demographic variables. But there were many across-the-board child experience effects, as we now discuss. The <u>direct effects</u> indicate that those who traveled alone by transit as a child exhibit a low propensity to own cars and a higher propensity to use transit in adulthood. Similarly, if the first impression of transit is positive, that contributes to a higher propensity of transit use in adulthood. As expected, if the individual's friends considered transit uncool, vehicle ownership propensity is higher. But, surprisingly, this same experience

appears to increase transit use propensity too, as evidenced by the positive coefficient. Growing up in a neighborhood with convenient transit contributes to a lower vehicle ownership propensity and a higher transit use propensity, and those who grew up without a commercial district nearby tend to exhibit lower levels of transit use propensity in adulthood. If the individual lived in a small town or rural neighborhood as a child, the effects of that built environment experience appear to linger with such individuals depicting higher propensity of vehicle ownership and lower propensity of transit use in later stages of life. These patterns are all consistent with expectations and suggest that exposure and experiences in childhood significantly impact choices and behaviors in adulthood. Also interesting is that the effects of childhood residence in small towns and rural areas increase vehicle ownership and reduce transit use, similar to the effects of current resident status. An interesting possibility then is that, with increasing urbanization over time, perhaps one will naturally see a decrease in vehicle ownership and an increase in transit use, due to the reinforcing effects of increasing childhood residence in urban areas combined with these individuals increasingly residing in urban areas in adulthood. The parental influence effects indicate that those whose parents considered it unsafe to ride public transit were likely to have a higher transit use propensity, which is again rather surprising. Interactions with different generations did not reveal variations in this effect across generations. One possible explanation is that, when adults perceive a level of substantial cognitive dissonance between what they were impressed upon when raised in an overprotective environment as children and what that they perceive in adulthood, they turn in the other direction of the original impression (*23*). The second parent influence variable "not encouraged to walk or bicycle places by parents" does not impact vehicle ownership, but does have a generational-based impact on transit use. In particular, when not encouraged to walk or bicycle places by parents during childhood, individuals currently belonging to the Millennials and Gen X generations have a low propensity to use transit, but this effect does not carry forward in the Baby Boomer and Silent Generations. This could be for one of many reasons. As indicated in the introduction section, this could be a true cohort culture effect attributable to "helicopter parenting" among more recent generations relative to earlier generations (leading to a more intense parental influence carryover among the younger generations) or simply a "distance from childhood" effect. Overall, the model provides evidence that childhood experiences (both direct and through parental influences shape choices and behaviors in adulthood.

The threshold estimates toward the bottom of the table do not have any substantive interpretations and simply allow the transformation from the continuous propensity to the ordinal categories in which the dependent variables are observed. The conditional tetrachoric correlation in the error terms (that is, the correlation in the underlying latent propensities of vehicle ownership and transit use, conditional on the determinant variables) is small in magnitude, yet statistically significant. The small magnitude suggests either that, conditional on the exogenous variables, there are few common unobserved factors affecting vehicle ownership propensity and transit use, or that there are common positive and negative factors that cancel out each other. By definition, these are correlations among unobserved factors, and so it is impossible to precisely identify the reasons for the small correlation magnitude. Regardless, accommodating the correlation coefficient through the joint bivariate model estimation is needed in the first place for consistent estimation of the model parameters, including the childhood experience variables. Only through such a joint estimation would we know whether or not the joint estimation is warranted.

4.2 Model Fit
The model offers a reasonable goodness-of-fit, consistent with what may be expected for joint models of disaggregate choice behaviors where the amount of data about built environment attributes is limited. The estimated model can be compared to a "base" model with only the constants and the thresholds in each of the ordinal equations (and no correlation across the ordinal equations) using a standard likelihood ratio test. The data fit of the final model and the "base" model were also evaluated intuitively and informally at both the disaggregate and aggregate levels. At the disaggregate level, the probability of the observed bivariate outcome for each individual is estimated and an average (across individuals) probability of correct prediction at this bivariate level is computed. At the aggregate level, a heuristic diagnostic check of model fit is designed by computing the predicted aggregate share of individuals in each of the twelve (four levels of vehicle ownership and three levels of transit use frequency) combination categories. The predicted shares from the final model and the base model are compared to the actual shares, and the absolute percentage error (APE) statistic is computed.

Table 2 shows the log-likelihood values of the final model and the base model are -16,820 and -22,092, respectively. The final model shows a better goodness-of-fit on the basis of likelihood ratio test. The adjusted rho-bar squared value with respect to the constants ("base") model is 0.24. The average probability of correct prediction is 0.27 for the proposed model, and 0.14 for the base model. The average APE (Absolute Percentage Error) is 19 percent for the joint model compared to 49 percent for the base model.

4.3 Size of Childhood Experience/Context Effect
The formulation in the online supplement is used to estimate the effects of the size of the childhood experience and parental influence. Figure 1 shows the proportion of total variance in the choice behaviors explained by the sets of variables considered in this study, including the proportion of unexplained variance. These proportions are computed for different demographic groups. Figure 1 shows that, compared to vehicle ownership propensity, there is a larger unexplained proportion for transit use propensity. In the absence of built environment attributes and transit level of service data, the unexplained portion of the propensity to use transit is inevitably going to be large. On the other hand, vehicle ownership in the United States is likely to be highly shaped by demographic and socio-economic variables as opposed to level of service variables. The results bear this out very clearly. While about 43 percent of the variance in vehicle ownership propensity remains unexplained by the factors considered in this paper, about 71 percent of the variance in transit use propensity remains unexplained (see the horizontal bars corresponding to TOTAL SAMPLE in Figure 1).

Figure 2 shows the portion of explained (as opposed to total) variance that may be attributed to each set of variables. For vehicle ownership, the DEM variable set accounts for close to 96 percent of the explained variance which is unsurprising as most characteristics used are closely tied to vehicle ownership (see the horizontal bar corresponding to TOTAL SAMPLE – vehicle ownership in Figure 2). The TRAN set of variables includes only residential location type in the vehicle ownership model, while the transit frequency model includes both residential location type and vehicle ownership. Overall, the childhood experience variables and the residential location type play a very small role in explaining vehicle ownership in later stages of life. It should be noted, however, that the childhood experience variables are largely related to transit use and residential location type; they are not about vehicle ownership. Hence, the small size effect of the childhood variables (and the lack of any parental influence effects) may partially

be due to the fact that the variables do not directly address vehicle ownership experiences in childhood. If the childhood and parental influence variables were descriptive of vehicle ownership and use during early years, then the size effect of DIRECT/PARENT may have been larger.

When it comes to transit use propensity, the DIRECT and TRAN variables play a more sizeable role in explaining behavior. Within the explained portion of transit use propensity, across the entire sample, DIRECT accounts for about 16 percent of the overall variance, PARENT accounts for 2 percent, TRAN accounts for about 27%, and DEM accounts for about 55% (see the last horizontal bar in Figure 2). When examining within generational cohorts, however, the DIRECT variables account for 21-32 percent of the explained portion of the variance, the TRAN variables account for 36-44%, and the DEM group accounts only for 24-37%. Compared to the case of vehicle ownership propensity, vehicle ownership and residential location type (TRAN) play a significant role in explaining transit use propensity; and demographic variables (DEM) collectively play a smaller role. Overall, while the DIRECT effect is undoubtedly significant, it does not appear to be all that large. Yet, it is substantially more influential than PARENT variables. Of the total variance in transit use propensity, DIRECT collectively accounts for just about 5 percent, with PARENT under 1 percent (see last horizontal bar of Figure 1), suggesting that frequency of transit use is largely governed by other built environment and attitudinal factors not included in the model (leading to the large unexplained portion).

5. CONCLUSIONS
This paper explores the role that childhood experiences, context, and parental influences may have in shaping adult travel behaviors and mobility choices. The study uses the 2014 WOBMAS data set, and presents a joint bivariate ordered probit model of vehicle ownership and frequency of transit use. The results show that childhood experience (both direct and parental influence) variables are significant in explaining both vehicle ownership and transit use propensity – thus confirming the hypothesis that choices in adulthood are shaped, at least in part, by opportunities, experiences, and influences accumulated in childhood.

The results were used to quantify the size of the direct and parent childhood experience effects. In general, based on this study's findings, it is rather uncertain whether interventions in childhood (directly or through parents) would be able to bring about significant shifts in choices later in life. What appears to have happened historically, based on the evidence gathered in this study, is that effects of childhood experiences and especially parental influences fade with age – and it is the prevailing socio-economic characteristics and built environment attributes that shape choices in adulthood.

This study is a unique examination of the influence of childhood experiences on adult travel behavior that controls for other demographic and transportation-related/built environment effects. Future research can shed additional light on the influence of childhood experiences through a more extensive capture of childhood experiences in activity-travel surveys as well as through a better representation of the built environment context in the analysis. Examining the relevance of early experiences also opens the door to further generation or cohort specific differences in mobility, as well as a disentangling of true "cultural" parenting practice variations across generations from a simple "distance from childhood" fading effect. The availability of surveyed responses at multiple stages of life, including dynamic demographics and attitudes such as income or changing values should be pursued for further behavior analysis and forecasting.

AUTHOR CONTRIBUTION STATEMENT
The authors confirm contribution to the paper as follows: study conception and design: K. Long, D. Capasso da Silva, F.F. Dias, S. Khoeini, A.C. Bhat, R.M. Pendyala, C.R. Bhat; data collection: Transit Center; analysis and interpretation of results: K. Long, D. Capasso da Silva, F.F. Dias, S. Khoeini, A.C. Bhat, R.M. Pendyala, C.R. Bhat; draft manuscript preparation: K. Long, D. Capasso da Silva, F.F. Dias, S. Khoeini, A.C. Bhat, R.M. Pendyala, C.R. Bhat. All authors reviewed the results and approved the final version of the manuscript.

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Millennial - Vehicle Ownership	37.4	60.5	1.7	0.4
Non-Millennial - Vehicle Ownership	46.2	51.2	2.0	0.6
Millennial & Gen X - Vehicle Ownership	38.1	59.8	1.7	0.4
Baby Boomer & Silent - Vehicle Ownership	47.7	49.7	2.0	0.6
Urban & Suburban - Vehicle Ownership	42.1	56.4	1.0	0.5
Town & Rural - Vehicle Ownership	45.9	52.5	1.1	0.5
White - Vehicle Ownership	45.1	52.4	2.0	0.5
Non-White - Vehicle Ownership	35.0	63.2	1.5	0.3
Presence of Children - Vehicle Ownership	40.6	57.1	1.8	0.5
No Children - Vehicle Ownership	45.1	52.3	2.1	0.5
TOTAL SAMPLE - Vehicle Ownership	42.5	55.0	2.0	0.5
Millennial - Transit Use	76.7	6.9 10.2 5.1		1.1
Non-Millennial - Transit Use	79.2	7.7 7.4 5.4		0.3
Millennial & Gen X - Transit Use	75.8	8.5 9.7 5.0		1.0
Baby Boomer & Silent - Transit Use	82.5	4.3 7.5 5.6		0.1
Urban & Suburban - Transit Use	70.9	16.3 7.4 4.8		0.6
Town & Rural - Transit Use	77.7	14.0 2.4 5.4		0.5
White - Transit Use	76.2	10.5 7.7 5.1		0.5
Non-White - Transit Use	74.5	9.3 10.4 4.9		0.9
Presence of Children - Transit Use	74.6	12.8 6.8 5.1		0.7
No Children - Transit Use	69.5	16.9 8.4 4.7		0.5
TOTAL SAMPLE - Transit Use	70.7	15.9 8.0 4.8		0.6

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Percent Explained by Various Effects

■ Unexplained   ■ DEM   ■ TRAN   ■ DIRECT (CHILD)   ■ PARENT (CHILD)

FIGURE 1 Percentage of Total Variance Attributable to Various Effects

	DEM	TRAN	DIRECT (CHILD)	PARENT (CHILD)
Millennial - Vehicle Ownership	96.7	2.7		0.6
Non-Millennial - Vehicle Ownership	95.3	3.7		1.0
Millennial & Gen X - Vehicle Ownership	96.6	2.8		0.6
Baby Boomer & Silent - Vehicle Ownership	95.0	3.9		1.1
Urban & Suburban - Vehicle Ownership	97.5	1.7		0.8
Town & Rural - Vehicle Ownership	97.0	2.0		1.0
White - Vehicle Ownership	95.4	3.6		1.0
Non-White - Vehicle Ownership	97.2	2.3		0.5
Presence of Children - Vehicle Ownership	96.1	3.1		0.8
No Children - Vehicle Ownership	95.2	3.8		1.0
TOTAL SAMPLE - Vehicle Ownership	95.8	3.4		0.8
Millennial - Transit Use	29.5	44.1	21.7	4.7
Non-Millennial - Transit Use	36.9	35.8	25.9	1.4
Millennial & Gen X - Transit Use	35.2	39.9	20.7	4.2
Baby Boomer & Silent - Transit Use	24.4	43.1	32.0	0.5
Urban & Suburban - Transit Use	56.1	25.6	16.3	2.0
Town & Rural - Transit Use	62.6	10.9	24.2	2.3
White - Transit Use	44.2	32.1	21.5	2.2
Non-White - Transit Use	36.7	40.7	19.0	3.6
Presence of Children - Transit Use	50.5	26.9	20.0	2.6
No Children - Transit Use	55.4	27.4	15.4	1.8
TOTAL SAMPLE - Transit Use	54.3	27.4	16.3	2.0

Percent Explained by Various Effects

DEM   TRAN   DIRECT (CHILD)   PARENT (CHILD)

FIGURE 2 Percentage of Explained Variance Attributable to Various Effects

TABLE 1 Opinion of Childhood Experience by Vehicle Ownership and Transit Use

Childhood Experience			Current Household Vehicle Ownership (%) N=10,404				Current Transit Usage Level (%) N=8,555	
Survey Statement & Opinion			0	1	2	3+	Transit User	Not Transit User
Direct	As a child, I traveled by myself on public transit	Agree	3.7	33.5	44.3	18.5	55.0	45.0
		Disagree	3.1	28.0	44.5	24.4	43.3	56.7
	My first impression of transit as a child was	Positive	3.3	32.3	45.0	19.4	55.6	44.4
		Negative	3.3	28.1	44.1	24.5	41.0	59.0
	My friends considered it 'uncool' to take transit	Agree	4.0	32.9	41.1	22.0	59.9	40.1
		Disagree	3.2	29.5	45.1	22.2	45.3	54.7
	I grew up in a neighborhood with convenient transit	Agree	4.2	34.1	43.3	18.4	55.5	44.5
		Disagree	2.7	27.0	45.3	25.0	41.7	58.3
	There was a commercial district (with retail stores and restaurants) that I could walk or bike to	Agree	3.3	30.7	44.5	21.5	51.2	48.8
		Disagree	3.3	29.0	44.5	23.2	42.0	58.0
	Childhood Location Type	Urban	5.5	35.7	41.0	17.8	57.3	42.7
		Suburb	2.5	29.2	45.2	23.1	46.7	53.3
		Small Town	2.7	26.9	45.7	24.7	43.3	56.7
		Rural	1.7	24.7	48.4	25.2	32.8	67.2
Parent	My parents thought it was unsafe to ride public transit	Agree	3.7	33.3	40.8	22.2	57.0	43.0
		Disagree	3.2	29.2	45.5	22.1	45.0	55.0
	As a child, I was encouraged to walk or bike places by my parents	Agree	2.6	29.0	45.8	22.6	48.9	51.1
		Disagree	4.8	32.3	41.7	21.2	45.5	54.5

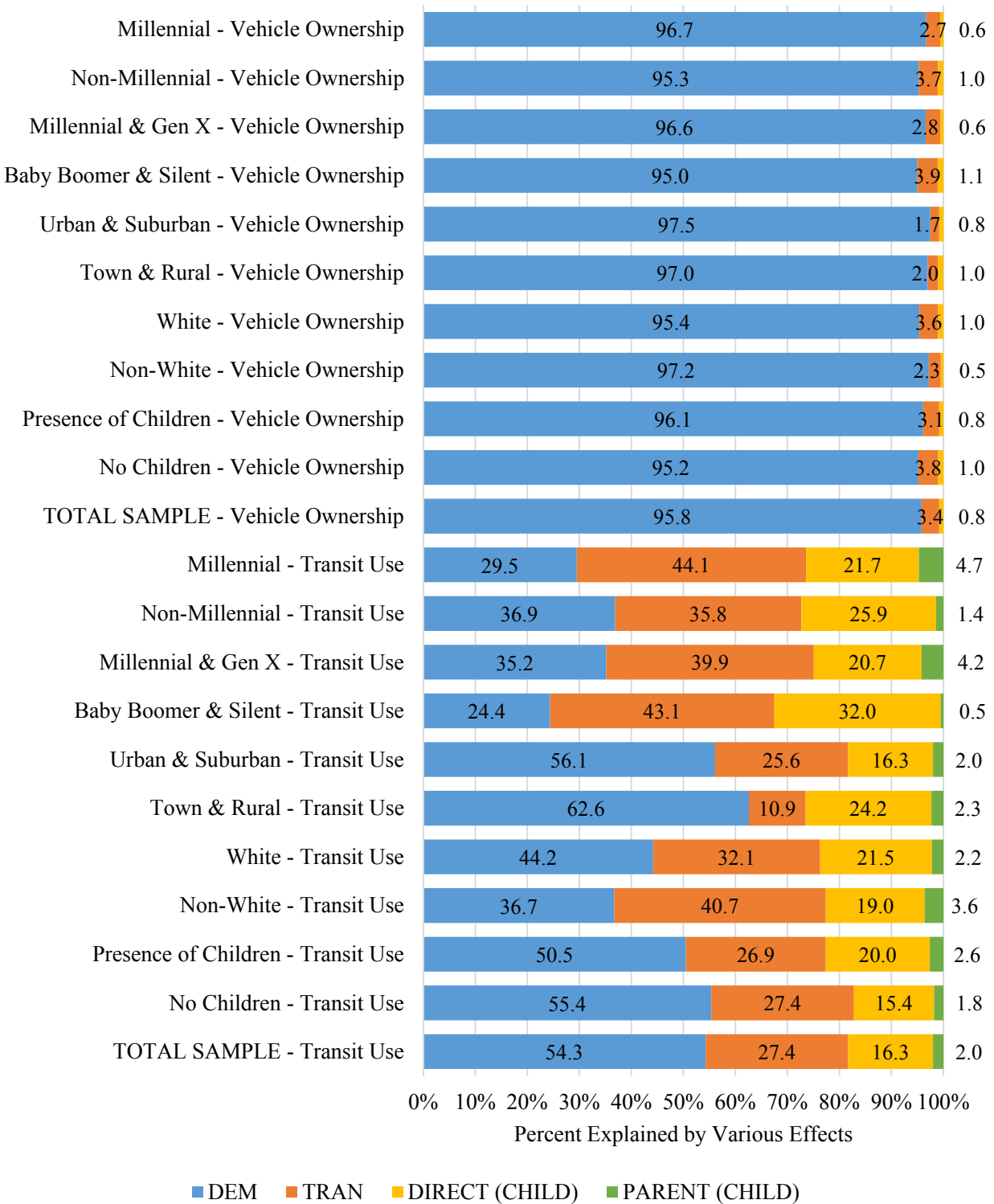**TABLE 2 Joint Model of Vehicle Ownership and Transit Use with Goodness-of-Fit Measures**

Independent Variables		Correlated Dependent Outcomes			
		Vehicle Own.		Transit Use	
		Coef.	T-Stat	Coef.	T-Stat
Demographics	Race *(Base: Non-Hispanic White)*				
	Non-White (Black, Asian, Hispanic-White, and Other)	-0.123	-4.004	0.440	13.308
	Household Income *(Base: $35,000-$100,000)*				
	Low - Below $35,000	-0.555	-12.459		
	High - Above $100,000	0.305	10.693	0.108	3.655
	Generation *(Base: Baby Boomer: 1946-1964)*				
	Millennial (1980-1998)	-0.318	-8.854	0.617	16.312
	Gen X (1965-1979)	-0.248	-4.874	0.332	7.302
	Silent Generation (1925-1945)	-0.135	-3.280		
	Presence of Children in HH: Yes *(Base: No)*	0.352	4.828	-0.080	-2.524
	Multi-Worker HH: Yes *(Base: No)*	0.272	9.338	0.162	4.623
	Person is Employed: Yes *(Base: No)*			0.221	7.019
	Number of Licensed Drivers in HH	1.245	71.175		
	Respondent has Driver's License: Yes *(Base: No)*			-0.472	-7.690
	Interaction: Millennial and Low Income	0.223	3.704		
	Interaction: Gen X and High Income	0.214	2.945		
	Interaction: Silent Generation and Low Income	0.346	3.369		
	Interaction: Presence of Children in HH and Number of Licensed Drivers in HH	-0.166	-5.424		
Transportation	Residential Location *(Base: Suburban)*				
	Urban	-0.329	-11.171	0.387	12.255
	Small Town	0.116	3.103	-0.193	-4.144
	Rural	0.424	10.302	-0.233	-3.986
	Household Vehicle Ownership *(Base: 0 vehicles)*				
	1 Vehicle			-0.805	-9.579
	2 or More Vehicles			-1.062	-11.016
Childhood Experiences	Direct	As a child, I traveled by myself on public transit *(Base: Disagree)*	-0.079	-2.827	0.192	6.002
		As a child, my first impression of transit was positive *(Base: Negative)*			0.272	9.096
		My friends considered it 'uncool' to ride public transit *(Base: Disagree)*	0.115	3.497	0.152	4.071
		I grew up in a neighborhood with convenient transit service *(Base: Disagree)*	-0.115	-4.096	0.090	2.793
		Grew up without a commercial district I could walk/bike to *(Base: Disagree)*			-0.127	-4.117
		Lived in a small town neighborhood *(Base: Suburban or Urban)*	0.080	2.530		
		Lived in a rural neighborhood *(Base: Suburban or Urban)*	0.093	2.280	-0.087	-1.706
	Parent	My parents thought it was unsafe to ride public transit *(Base: Disagree)*			0.103	3.022
		Interaction: Not encouraged to walk/bike places and Millennial or Gen X			-0.215	-5.674
Thresh.	Threshold 1	-0.583	-10.825	-0.531	-5.939
	Threshold 2	1.689	36.304	0.387	4.303
	Threshold 3	3.463	73.411		
	Correlation Term	Coef: -0.063		T-Stat: -2.973	

Goodness-of-Fit Summary Statistics	Joint Model	"Base" Model
Log-Likelihood Value at Convergence	-16,820	-22,092
Number of Parameters	47	5
Adjusted Rho-Bar Squared Value	0.237	
Nested Likelihood Ratio Test Between the Two Models (p=0.000)	10,545 with 42 Degrees of Freedom	
Average Probability of Correct Prediction	0.269	0.141
Average Absolute Percentage Error (APE)	19%	49%