**Walking (and cycling) to well-being: Modal and other determinants of subjective well-being during the commute**

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**Abstract**

Although transportation's impacts on physical health are relatively well-established, the relationship between transportation and subjective well-being (SWB) has been the subject of recent focus. Policymakers attempt to improve the health and well-being of populations through interventions to improve transportation experiences and promote sustainable transport modes, while researchers studying these connections seek valid and reliable measures of SWB in the travel domain. Studies consistently find travel by walking and bicycling to be rated more positively than automobile travel, yet many use single measures of travel SWB, obscuring nuanced variations between modes.

Using the results of a Portland, Oregon, survey of nearly 700 commuters, this study investigates modal differences and other potential determinants of detailed, multidimensional measures of travel SWB. Specifically, the Satisfaction with Travel Scale as well as new measurement models of travel affect (distress, fear, attentiveness, and enjoyment) and travel eudaimonia (security, autonomy, confidence, and health) are examined for variations between modes. Structural equation models predicting the latent variable constructs as a function of trip and traveler characteristics yield valuable behavioral and psychological insights. Walking and bicycling rated much higher on measures of physical and mental health, confidence, positive affect, and overall hedonic well-being, suggesting significant benefits of physically active commutes. However, cycling commuters scored higher on distress and fear and lower on security, highlighting the value of multidimensional measures of travel SWB. Enhancing the quality of the traveling experience by various modes—such as making bicycling feel safer through protected infrastructure—could significantly improve commuters' well-being.

**Keywords**

Subjective well-being; Active transportation; Satisfaction with Travel Scale; Affect; Eudaimonia

# 1 Introduction

The relationship between transportation and population health and well-being has been the focus of increased attention in the research community (De Vos, Schwanen, Van Acker, & Witlox, 2013; De Vos & Witlox, 2017; Nordbakke & Schwanen, 2014). Most reviews of these relationships focus on system-wide mechanisms by which transportation can affect well-being (Delbosc, 2012; Reardon & Abdallah, 2013): through the economy, the environment, social relationships, and individuals' mobility and accessibility. This trend follows a broader interest in using public health (of which physical activity is a critical element) and well-being concepts and metrics for transportation and other policymaking (Diener, Lucas, Schimmack, & Helliwell, 2009; Singleton & Clifton, 2017): e.g., "gross national happiness" over gross national product (Bates, 2009).

At a more individual level, applications of psychological approaches to well-being within the travel behavior field have grown in number. *Subjective well-being* (SWB) is a conceptualization of well-being interpreted through the lens of an individual's perceptions and experiences. It is typically categorized into hedonic (satisfaction and positive feelings and mood) and eudaimonic (finding purpose, meaning, or self-actualization) components (De Vos et al., 2013). A common conceptualization of hedonic SWB contains positive and negative affect (short-term presence/absence of positive emotions) and cognitive evaluation (long-term satisfaction with life) elements (Diener, 1984). Further motivating research linking travel to SWB is an interest in understanding and measuring the positive utility of travel (PUT) concept (Mokhtarian & Salomon, 2001; Salomon & Mokhtarian, 1998; Singleton, 2017) and other non-instrumental reasons for traveling (Mokhtarian, Salomon, & Singer, 2015).

Informing transportation planning and policymaking, research has begun to analyze potential transportation determinants of SWB in general and SWB for specific travel situations. Many studies find travel by walking and bicycling to be rated more positively than travel by automobile. Unfortunately—as will be made clear in the literature review below—a number of research challenges emerge. Notably, most psychological instruments used to measure SWB have not been examined in and/or are difficult to apply to the travel domain. One exception is the Satisfaction with Travel Scale (Ettema et al., 2011), although it too has been used in only a handful of situations. Furthermore, many studies use single measures of travel SWB, simplifying its complex nature and obscuring more nuanced variations between modes. Even if strong measures are used, the potentially bidirectional or cyclical relationships between travel satisfaction or well-being, travel attitudes, and mode choices (De Vos & Witlox, 2017) are challenging to disentangle. Finally, like attitudes, perceptions, and other psychosocial factors, SWB can be difficult to forecast and use in a planning framework. If socio-demographic traveler characteristics can be consistently and significantly associated with SWB, these objective measures could substitute for more subjective measures in travel demand modeling and analysis tools. These challenges and opportunities motivate this work.

This study aims to address the following broad research question: What traveler and trip characteristics are associated with multidimensional measures of SWB in the travel domain? More specifically: Are there specific SWB constructs where walking and bicycling rate higher or lower than other modes? Are trip or traveler characteristics more predictive of travel SWB ratings? The following sections examine these questions through the analysis of a 2016 commuting survey in Portland, Oregon. First, literature on measures and determinants of SWB are reviewed. Next, data and methods are summarized, including measurement models of hedonic, affective, and eudaimonic travel well-being. The results of structural equation models analyzing associations

with each facet of travel SWB are then presented. Finally, key findings are discussed, including implications for understanding active transportation motivations, policymaking, and opportunities for future work.

# 2 Literature review

## *2.1 Measuring travel well-being*

Several well-established psychometric instruments exist for measuring retrospective SWB, most using Likert-type or semantic differential scales (De Vos et al., 2013; Ettema, Gärling, Olsson, & Friman, 2010; Mokhtarian, 2015). For example, measures include: the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988) and the Swedish Core Affect Scale (SCAS) (Västfjäll et al., 2002) for affective hedonic SWB; the Satisfaction with Life Scale (Diener, Emmons, Larsen, & Griffin, 1985) for cognitive hedonic SWB; and the Flourishing Scale (Diener et al., 2010) for eudaimonic SWB. The abundance of SWB questionnaires helps to explain why SWB approaches (especially hedonic ones) have begun to be analyzed in transportation studies (Nordbakke & Schwanen, 2014). Nevertheless, while some instruments (like PANAS) can be used over different temporal scales, many cognitive and eudaimonic items focus on life in general and cannot be easily translated to a shorter time-frame or to a particular domain. Furthermore, most standard SWB metrics have not been comprehensively tested or applied in the transportation area, a need that motivates this research.

One exception is the Satisfaction with Travel Scale (STS), a measure of hedonic SWB specific to the travel domain (Ettema et al., 2011). Based on the SCAS, the STS includes nine pairs of adjectives or statements on a seven-point (−3 to +3) semantic differential scale, together representing three aspects of travel SWB or travel satisfaction: core affect as ranging from negative activation to positive deactivation, core affect from negative deactivation to positive activation, and cognitive evaluation. Applications of the STS have increased in recent years and now include studies from multiple countries and of both commute and non-commute travel contexts (De Vos, Schwanen, Van Acker, & Witlox, 2015; Ettema, Gärling, Olsson, Friman, & Moerdijk, 2013; Friman, Fujii, Ettema, Gärling, & Olsson, 2013; Smith, 2017; Suzuki et al., 2014; Ye & Titheridge, 2017; Zhao & Lee, 2013).

More commonly, quantitative research in this area uses ad-hoc measures of hedonic aspects of travel SWB that ask about overall satisfaction with or liking of travel in general or travel by specific modes or for various purposes. While travel satisfaction questions are likely more about cognitive evaluation than positive/negative affect (De Vos et al., 2013), they may be partially measuring some emotional aspects or even values of productive travel time use. In comparison, travel liking questions (Ory & Mokhtarian, 2005) likely measure travel affect. Less common travel affect questions investigate pleasantness, happiness, enjoyment, relaxation, excitement, and more (Singleton, 2017).

Relatively scant attention has been paid to travel eudaimonia, at least among quantitative studies, perhaps because eudaimonic responses to travel or symbolic motivations for traveling may be more implicit and challenging to measure in a questionnaire format. Work in this area has been more qualitative, focusing on the psychosocial benefits of travel and noninstrumental reasons for traveling, often for the purposes of understanding driving and car use behaviors (Gatersleben, 2014; Steg, 2005) or studying mobility from a sociological perspective (Watts & Urry, 2008). The travel behavior field could benefit from more reliable and comprehensive scales for measuring travel well-being, especially with respect to affective and eudaimonic aspects.

### *2.2 Determinants of travel well-being*

Examinations of the transportation–SWB relationship at an individual level have summarized several pathways by which travel can affect well-being (De Vos et al., 2013; Ettema et al., 2010; Mokhtarian, 2015; Nordbakke & Schwanen, 2014). Among the most relevant paths are those influencing short-term trip-specific SWB through travel experiences during destination-oriented travel, and instances where travel is the activity (e.g., outdoor recreation). Given that transportation affects SWB, it logically follows that expectations or concerns about travel-related well-being could influence travel decisions and behaviors. For instance, travelers may consider expected short-term SWB impacts when choosing travel modes or routes (Abou-Zeid & Ben-Akiva, 2014). Scholars have acknowledged this bidirectional relationship (De Vos et al., 2013; De Vos & Witlox, 2017; Mokhtarian, 2015), but relatively few studies have empirically examined potential determinants of SWB in the travel domain. A summary of findings from those studies follows.

Not surprisingly, several trip and transportation characteristics appear to be associated with travel well-being. Modal effects are prominent; transport modes' inherent differences directly affect travel experiences and how each mode acts as a symbol. Travel SWB—measured in ways including the STS, travel satisfaction, and travel liking—is consistently rated more positively for walking and bicycling than for automobile travel, and public transit use is often rated more negatively (Anable & Gatersleben, 2005; De Vos et al., 2013; De Vos et al., 2015; De Vos, Mokhtarian, Schwanen, Van Acker, & Witlox, 2016; Duarte et al., 2010; Ettema et al., 2011; Friman et al., 2013; Gatersleben & Uzzell, 2007; LaJeunesse & Rodríguez, 2012; Mao, Ettema, & Dijst, 2015; Martin, Goryakin, & Suhrcke, 2014; Morris & Guerra, 2015a; Olsson et al., 2011; Rhee, Kim, Lee, Kim, & Lee, 2013; Smith, 2017; St-Louis, Manaugh, van Lierop, & El-Geneidy, 2014; Susilo et al., 2017; Thomas & Walker, 2015; Turcotte, 2006; Ye & Titheridge, 2017; Zhao & Lee, 2013). Some modal differences may result from availability limitations and self-selection: People who walk and bicycle often may live in places with more options, while some people who drive or use transit may have fewer alternatives. Yet, it is more likely that these differences result from intrinsic characteristics of the modes themselves: Walking and bicycling are physically active activities that take place outdoors; traveling by transit involves sharing space in close proximity to strangers; and car commuters in major cities often experience congestion.

Travel time and trip purpose may also affect travel well-being. Satisfaction with the travel experience and travel liking tends to decrease with longer trip distances or durations (Milakis, Cervero, van Wee, & Maat, 2015; Morris & Guerra, 2015b; Olsson et al., 2011; Ory & Mokhtarian, 2005, 2009; Rasouli & Timmermans, 2014a; Smith, 2017; Stone & Schneider, 2016; Susilo et al., 2017; Turcotte, 2006; Wachs et al., 1993). However, more-detailed studies indicate that travel time may be nonlinearly associated with travel SWB, increasing to a peak at around 15 minutes before decreasing with a long tail (Milakis et al., 2015; Wachs et al., 1993; Young & Morris, 1981). Long-distance travel is liked more than short-distance travel (Mokhtarian & Salomon, 2001), but this may be partially due to confounding travel liking with liking activities at the destination (e.g., recreational travel, tourism, visiting family and friends). Within short-distance travel, work and school commutes seem to be less positive than trips for other purposes (Mokhtarian, Papon, Goulard, & Diana, 2015; Mokhtarian & Salomon, 2001; Morris & Guerra, 2015a; Ory & Mokhtarian, 2005), perhaps due to anticipation of or preparation for these mandatory activities.

Notably, few objectively measured demographic or socioeconomic traveler characteristics are consistently associated with SWB in the travel domain. An exception is age: Satisfaction with travel, a positive affect about travel, and travel-related SWB (for a particular trip) appear to be

higher among older travelers (Archer, Paleti, Konduri, Pendyala, & Bhat, 2013; Jakobsson Bergstad et al., 2011; Mokhtarian, Papon et al., 2015; Olsson et al., 2011; Ory & Mokhtarian, 2005; Rasouli & Timmermans, 2014a, 2014b; St-Louis et al., 2014; Ye & Titheridge, 2017). This finding may suggest the importance of broader life stage, lifestyle, or cultural influences that transcend more traditional socio-demographic measures. Indeed, the attitudes and personalities of travelers seem to be more directly linked to travel well-being (De Vos et al., 2016; Ory & Mokhtarian, 2009; Steg, 2005; St-Louis et al., 2014); e.g., pro-environmental attitudes were associated with travel liking for nonautomobile modes (Ory & Mokhtarian, 2005).

This review highlights the need for further research to identify additional determinants of travel SWB, particularly with respect to traveler characteristics. There is also a need to examine attitudes and nontraditional socio-demographic attributes more closely. Further, most associations have been with single-item measures such as travel liking or travel satisfaction; using multidimensional measures of travel SWB could illuminate more nuanced relationships. Finally, even studies that analyze more complex measures like the STS still focus on hedonic SWB, leaving eudaimonic aspects nearly untouched. This study attempts to rectify some of these limitations.

## 3 Data and methods

As part of a larger study investigating the positive utility of travel (PUT) concept and the effects of a PUT on mode choice (Singleton, 2017), this analysis is based on data collected from a 30-minute online questionnaire survey administered to working and commuting adults in the Portland, Oregon, region. Respondents provided detailed information about their most recent commute trip from home to work, including answering questions about travel affect, travel eudaimonia, and the STS. Data collection lasted from mid-October to mid-December 2016, with most participants recruited via email at their workplace. Of the 791 people who started the survey, only 682 respondents completed enough questions to be used in these analyses, and more were removed during the modeling process due to item non-response. Descriptive statistics of the sample are shown in Table 1.

The sample was relatively representative of the Portland area working population, with a two major exceptions. First, the sample included proportionately more bicycle and transit commuters and fewer auto commuters than the region as a whole. This was by design: The study recruited participants from areas of the region (such as Downtown or along light rail corridors) where nonauto modes were more attractive and available, in order to ensure sufficient modal sample sizes for a subsequent mode choice analysis. Second, the sample was skewed towards higher-income workers and away from lower-income workers. This was likely a byproduct of both sampling and response biases: The survey reached many office workers in government and large companies, occupations and industries that may pay higher wages; and lower-income workers may not have had as much free time or computer access to complete the survey. The difficulty reaching a lower-income population is a common travel survey issue (Bradley, Bergman, Lee, Greene, & Childress, 2015). More information on the data collection process can be found in Singleton (2017).

### *3.1 Measures of commute well-being*

Three types of travel well-being measures were employed in this study: those pertaining to the Satisfaction with Travel Scale, travel affect, and travel eudaimonia. After data collection, exploratory and confirmatory factor analysis (EFA/CFA) yielded measurement models of each of these latent constructs; see Figure 1. This section briefly describes the three travel SWB

measurement scales and resulting latent factors; more information on their measurement structure can be found elsewhere (Singleton, 2017). In turn, the latent variables are the dependent variables for the purposes of this analysis.

### *3.1.1 Satisfaction with Travel Scale*

The Satisfaction with Travel Scale (STS) measures hedonic SWB and consists of nine paired items measured on seven-point semantic differential scales. The version in this study used the items developed by Ettema et al. (2011) with revisions such as those suggested by Smith (2017). For each pair of statements (one to the left, one to the right), respondents were instructed to "select the choice that best corresponds to your overall experience traveling on your most recent commute to work." The item pairs were: "I was very…" distressed/content, tense/relaxed, sad/happy, tired/energized, bored/enthusiastic; "My trip…" was displeasing/enjoyable, went poorly/smoothly, was the worst/best I can imagine; and "I was worried I wouldn't / confident I would arrive on time."

Based on the EFA results and previous work with the STS, a three-factor CFA model ($N$ = 656) was estimated using maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic (Satorra & Bentler, 1994), which is robust to the nonnormality of the observed item responses. The model provided an adequate statistical fit to the data (CFI = 0.967, TLI = 0.951, RMSEA = 0.080, SRMR = 0.031). Conceptually, the three factors matched those suggested by the literature: "Positive deactivation," "Positive activation," and "Cognitive evaluation." All standardized loadings were large but not too large ($0.60 < \lambda < 0.90$), and all three constructs had adequate internal reliability (Cronbach's $\alpha > 0.70$); however, correlations between the latent variable disturbances were somewhat high (0.79–0.89), suggesting potential overlapping concept or a second-order construct.

### *3.1.2 Travel affect*

Measures of affective travel well-being utilized a PANAS-type approach, with items rated on a five-point Likert-type scale. Following the PANAS, respondents were instructed to first think "about yourself and your most recent commute to work," and then "indicate to what extent you felt" each of 20 adjectives while commuting by their chosen transportation mode. The first block of travel affect questions were the 10 items from the international short-form version (I-PANAS-SF) (Thompson, 2007): upset, hostile, alert, ashamed, inspired, nervous, determined, attentive, afraid, and active. The remaining 10 items—excited, strong, vulnerable, proud, angry, bold, frustrated, timid, calm, and stressed—were selected after a multistage process involving a review of psychological affect scales and travel behavior literature as well as a small pilot study.

After dropping two items based on the EFA results, a four-factor CFA model ($N$ = 682) was estimated, again using robust maximum likelihood estimation with Satorra-Bentler scaling. The model exhibited adequate statistical fit to the data (CFI = 0.923, TLI = 0.909, RMSEA = 0.063 (CI = 0.056 to 0.071), SRMR = 0.060). Conceptually, the measurement model well represented a four-factor structure of positive and negative travel affect, with two moderately correlated (0.42) negative constructs ("Distress" and "Fear") and two moderately correlated (0.49) positive constructs ("Attentiveness" and "Enjoyment").

### *3.1.3 Travel eudaimonia*

Existing eudaimonic SWB instruments were difficult to adapt to the travel domain, so new questions and items were created following a similar multistage process as was used to develop

the travel affect measures. Respondents were told: "Thinking about your most recent commute to work, did commuting allow you, at least a little, to…" do one of three things, reflecting potential motivations for travel. Respondents could select multiple items from a list of 22 words and phrases. The first group was about "fulfill[ing] your desire for" the following: variety, control, adventure, companionship, freedom, privacy, safety, comfort, stress relief, a routine, a challenge, a buffer between home and work, or membership in a group or class. The remaining two groups were about "expressing" independence, social status, self-identity, courage, mastery of a skill, or environmental values; or "improving" self-confidence, mental health, or physical health.

Models of travel eudaimonia were more complex and challenging to fit, and eight items were removed based on the EFA results and due to concerns about discriminant validity. The remaining items went into a four-factor CFA model ($N$ = 680), employing diagonally weighted least squares estimation with robust standard errors and a mean-and-variance adjusted test statistic, due to the binary nature of the data. The model exhibited good fit statistics (CFI = 0.971, TLI = 0.963, RMSEA = 0.052, SRMR = 0.072) and adequate standardized loadings. The four constructs identified—"Security," "Autonomy," "Confidence," and "Health"—were intuitive and reasonably distinct, although latent variable disturbances were more strongly correlated than in the travel affect model. Nevertheless, the four factors do mirror findings from the literature about eudaimonic concepts that have been associated with travel behavior.

### *3.2 Analysis methods*

After developing CFA measurement models for each concept (the STS, travel affect, and travel eudaimonia), potential determinants of travel well-being were examined by estimating structural equation models (SEMs) in which exogenous variables predicted each CFA's latent variables, also known as multiple indicators, multiple causes (MIMIC) models. The MIMIC models were estimated using the lavaan package (Rosseel, 2012) in R. For the purposes of this study, the exogenous variables included trip characteristics, weather, traveler demographics and socioeconomics, and traveler perceptions. A self-reported measure of travel usefulness was also included to control for the possibility that measures of travel SWB may have captured some degree of satisfaction with travel-based multitasking (a different component of the PUT concept). Before the independent variables entered the model, they were examined for multicollinearity issues; variables that were moderately-to-strongly correlated (> 0.40) were removed. See Table 1 for a full list of the independent variables and their descriptive statistics. Figure 1 displays the MIMIC model setup, including each of the travel SWB latent variables.

**Table 1 Descriptive statistics**

| | *Categorical* | | *Continuous* | |
|---|---|---|---|---|
| *Variable* | *#* | *%* | *Mean* | *SD* |
| *Trip characteristics* | | | | |
| Mode: Walk | 30 | 4.3 | | |
| Bicycle | 114 | 16.5 | | |
| Transit | 175 | 25.4 | | |
| Auto, passenger | 35 | 5.1 | | |
| Auto, driver | 336 | 48.7 | | |
| Travel time (minutes) | | | 35.66 | 21.27 |
| # cotravelers | | | 0.24 | 0.70 |
| Temperature (°F) Δ from average | | | 2.71 | 5.15 |

| | Categorical | | Continuous | |
|---|---|---|---|---|
| *Variable* | *#* | *%* | *Mean* | *SD* |
| Day precipitation ≥ 0.10 in | 155 | 22.9 | | |
| *Traveler socio-demographics* | | | | |
| Age: 18–34 years | 142 | 19.4 | | |
| 35–44 years | 190 | 25.9 | | |
| 55–64 years | 174 | 23.7 | | |
| 65+ years[1] | 48 | 6.5 | | |
| Gender: Female | 403 | 55.4 | | |
| Race/ethnicity: Missing | 24 | 3.3 | | |
| Hispanic/non-white/multiple | 101 | 13.7 | | |
| Disability | 54 | 7.3 | | |
| Student | 54 | 7.3 | | |
| Education: No college degree | 131 | 17.9 | | |
| Graduate degree | 318 | 43.4 | | |
| # children (age ≤ 16) | | | 0.41 | 0.81 |
| # workers | | | 0.51 | 0.71 |
| # seniors (age 65+) | | | 0.06 | 0.28 |
| Income: $0–50k | 64 | 8.7 | | |
| $50–75k | 125 | 17.0 | | |
| $100–150k | 196 | 26.6 | | |
| $150k+ | 135 | 18.3 | | |
| Missing | 55 | 7.5 | | |
| Multifamily home[2] | 148 | 20.6 | | |
| Lived in home: 0–5 years | 306 | 42.6 | | |
| # cars | | | 1.74 | 1.03 |
| # bicycles | | | 2.46 | 2.03 |
| Car-share member | 173 | 23.8 | | |
| Bike-share member | 70 | 9.6 | | |
| Transit pass | 307 | 42.2 | | |
| # commute days | | | 4.62 | 0.89 |
| # hours worked | | | 42.34 | 10.25 |
| Flexible work schedule | 451 | 62.8 | | |
| Self-employed | 33 | 4.6 | | |
| *Traveler perceptions* | | | | |
| Typical travel time: Dissatisfied | 239 | 34.2 | | |
| Ideal travel time (minutes) | | | 13.70 | 8.76 |
| Teleportation[3]: No | 261 | 37.5 | | |
| Travel usefulness: Mostly wasted | 81 | 11.8 | | |
| Somewhat wasted | 128 | 18.7 | | |
| Somewhat useful | 176 | 25.7 | | |
| Mostly useful | 157 | 22.9 | | |

[1] Most participants aged 65+ reported working outside the home, at least part time. In addition, the commuting survey encouraged non-working respondents to consider regular volunteer responsibilities as work.

| | *Categorical* | | *Continuous* | |
|---|---|---|---|---|
| *Variable* | *#* | *%* | *Mean* | *SD* |

[2] In a U.S. context, a multifamily home is a housing unit that is located in a structure with other housing units, including a duplex and an apartment building or condominium.
[3] This question administered the hypothetical "teleportation test" (Russell & Mokhtarian, 2015), asking if people would prefer to teleport or to spend some time commuting, if the technology were available and safe.

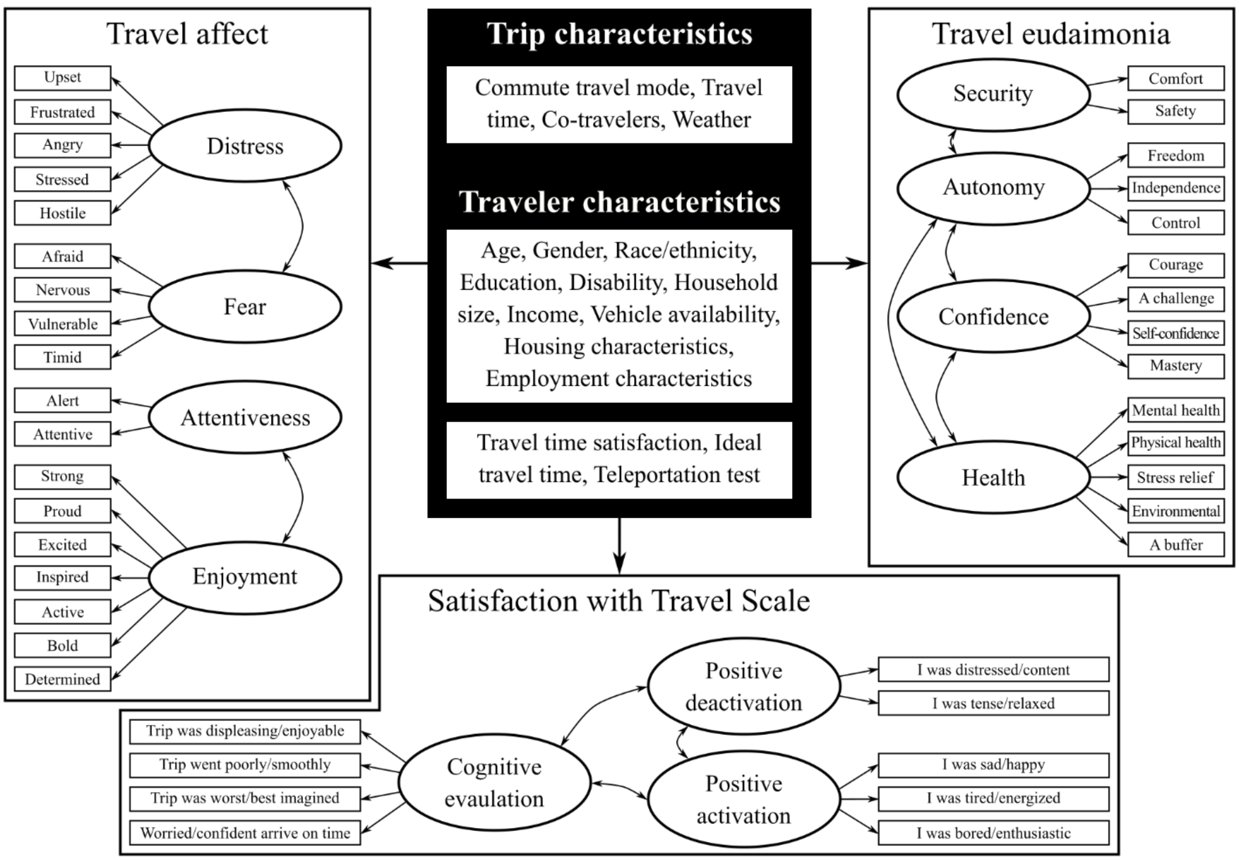


**Figure 1 MIMIC model setup and latent variables of travel SWB**

# 4 Results

## *4.1 Satisfaction with Travel Scale*

Figure 2 presents the distributions of the three individual standardized factor scores for the STS, calculated from the CFA and summarized using box-and-whisker plots for each commute mode. The box plots for each group show a thick horizontal line at the median, the interquartile range (25th to 75th percentiles) within the box, and whiskers extending to 1.5 times the interquartile range; outliers are represented by dots located beyond the whiskers. There appear to have been significant modal differences on the factor scores, but these differences were roughly stable across STS constructs, as would be expected by the highly correlated latent variables. Overall, walking and bicycling commuters reported higher-than-average travel satisfaction ratings, especially on the items making up "Cognitive evaluation." Transit riders and auto passengers had

roughly average ratings; auto drivers had the lowest STS scores, on average. Despite these modal trends, there was large variation in STS even within modes, suggesting a role for additional explanatory factors.

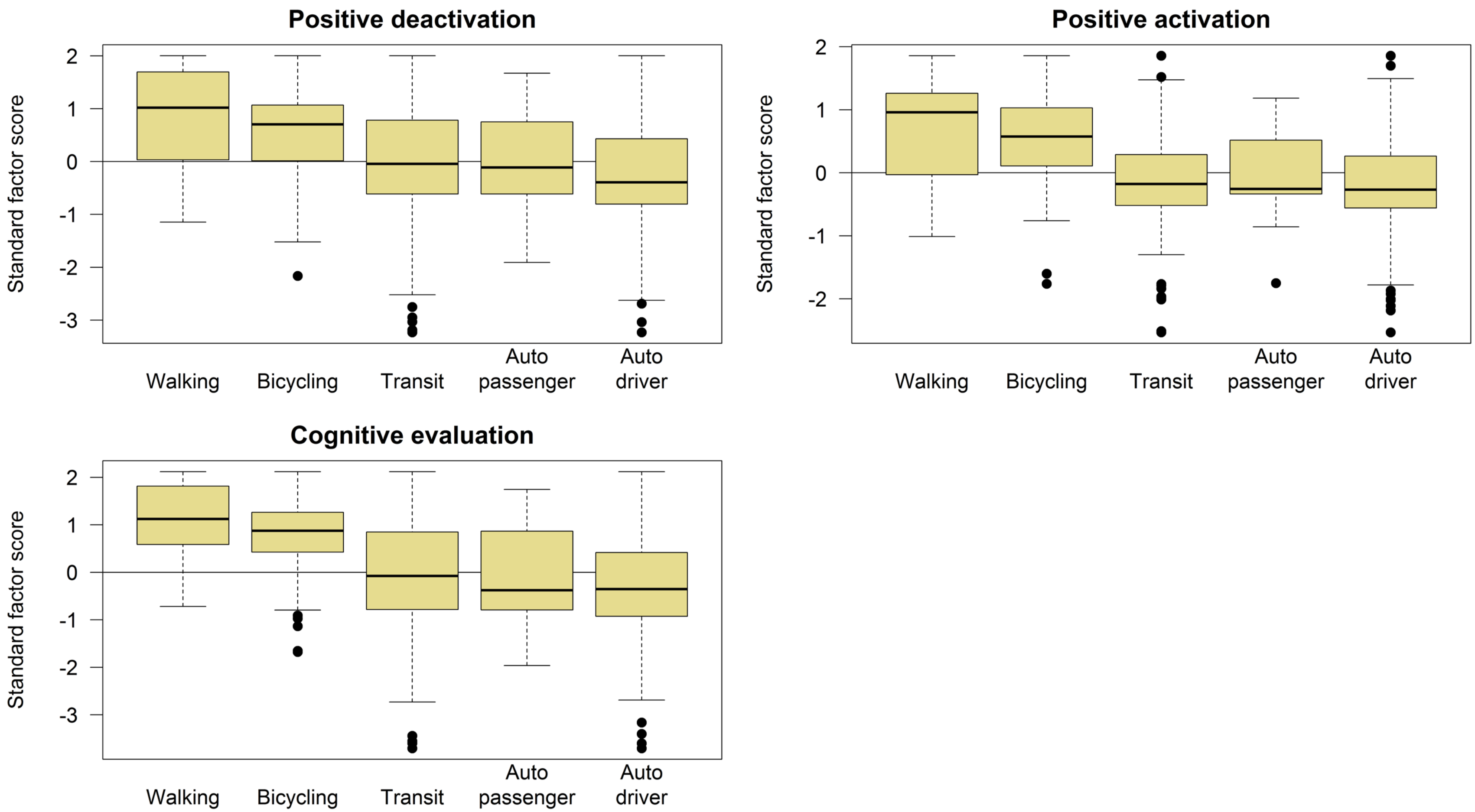


**Figure 2 Box plots of STS factor scores by commute mode**

To examine other potential determinants of the STS, MIMIC models were estimated using the exogenous trip and traveler characteristics of Table 1 to predict the three STS latent variables. Model estimation results for the regression portions of the MIMIC models are presented in Table 2; only variables with marginally significant associations ($p \leq 0.10$) are shown. (Full model results may be obtained by contacting the author.) The trip and traveler characteristics explained between a third and a half of the variance in the latent variables, with lower fit for the "Positive deactivation" construct ($R^2$ = 0.34) and higher fits for "Positive activation" ($R^2$ = 0.46) and "Cognitive evaluation" ($R^2$ = 0.49).

**Table 2 MIMIC model results for the STS**

| *N = 621* | *Positive deactivation* | | *Positive activation* | | *Cognitive evaluation* | |
|---|---|---|---|---|---|---|
| | *B* | *p* | *B* | *p* | *B* | *p* |
| *Trip characteristics* | | | | | | |
| Mode: Walk | 0.520 | 0.068 ~ | 0.850 | 0.012 * | 0.722 | 0.008 * |
| Bicycle | 0.033 | 0.855 | 0.504 | 0.010 * | 0.250 | 0.135 |
| Transit | 0.369 | 0.025 * | −0.141 | 0.360 | 0.187 | 0.195 |
| Auto, passenger | 0.189 | 0.393 | −0.005 | 0.981 | 0.182 | 0.392 |
| Travel time (minutes) | −0.010 | 0.002 * | −0.002 | 0.451 | -0.010 | 0.002 * |
| *Traveler socio-demographics* | | | | | | |
| Gender: Female | −0.175 | 0.079 ~ | −0.254 | 0.011 * | −0.103 | 0.281 |
| Disability | −0.372 | 0.052 ~ | −0.336 | 0.084 ~ | −0.423 | 0.043 ~ |
| Student | −0.258 | 0.116 | −0.082 | 0.640 | −0.331 | 0.034 * |
| Income: 150k+ | 0.146 | 0.340 | 0.188 | 0.237 | 0.248 | 0.087 ~ |
| # commute days | 0.126 | 0.050 ~ | 0.013 | 0.827 | 0.022 | 0.705 |
| Self-employed | 0.316 | 0.240 | 0.474 | 0.078 ~ | 0.411 | 0.100 ~ |
| *Traveler perceptions* | | | | | | |
| Typical travel time: | | | | | | |
| Dissatisfied | −0.226 | 0.041 * | −0.221 | 0.050 * | −0.370 | 0.000 * |
| Travel usefulness: | | | | | | |
| Mostly wasted | −0.551 | 0.003 * | −0.644 | 0.000 * | −0.530 | 0.003 * |
| Somewhat wasted | −0.143 | 0.300 | −0.200 | 0.129 | −0.055 | 0.667 |
| Somewhat useful | 0.094 | 0.471 | 0.109 | 0.393 | 0.357 | 0.004 * |
| Mostly useful | 0.537 | 0.004 * | 0.518 | 0.004 * | 0.692 | 0.000 * |
| *Model fit statistics ($R^2$)* | | | | | | |
| Trip only | 0.162 | | 0.249 | | 0.287 | |
| Socio-demo only | 0.124 | | 0.156 | | 0.151 | |
| Perceptions only | 0.220 | | 0.285 | | 0.362 | |
| $R^2$ overall | 0.342 | | 0.455 | | 0.485 | |

Statistical significance: * = $p \leq 0.05$, ~ = $p \leq 0.10$.
Variables having coefficients with $p > 0.10$ for all factors are not shown.

After controlling for other factors, commute mode remained a significant factor. People walking had higher scores on all STS factors than did auto drivers. Transit riders had higher "Positive deactivation" scores and bicycle commuters had higher "Positive activation" scores. Travel time also appeared to be a determinant of the STS: Longer duration trips were rated more negatively overall, although not for the PA construct. Nonlinear (logarithmic, quadratic) representations of travel time did not significantly improve model fit. A model (not shown) in which travel time was interacted with commute mode found that its negative effect was relatively

constant across modes; however, significant residual modal effects disappeared when controlling for mode-specific travel times.

Only a few socio-demographic traveler characteristics appeared to be determinants of the STS. Overall, women, students, and people with disabilities all reported lower levels of satisfaction with their commutes. People who were self-employed had higher STS scores, and more-frequent commuters reported higher levels of less-active positive affect. Traveler socio-demographics contributed a smaller portion of explained variance in the latent variables than variables of other types. Instead, traveler perceptions dominated. People who were dissatisfied with their typical commute travel times also reported lower levels of travel well-being. The subjective travel usefulness measure was also a significantly factor: Travelers with more useful commutes also had higher STS scores.

### *4.2 Travel affect*

To systematically examine modal differences, standardized factor scores of the four travel affect latent variables from the CFA were analyzed; box-and-whisker plots for each factor by mode are shown in Figure 3. Ratings of "Distress" were low overall but slightly higher for auto drivers and bicycle riders, with some positive outliers especially for transit riders and auto drivers. Scores on the "Fear" factor were also low across the board but positively skewed (with several outliers for auto drivers, in particular), although bicycle commuters exhibited much higher levels on average. Ratings of "Attentiveness" showed high variability within modes, but overall, bicycle commuters scored higher on this construct and transit riders and auto passengers scored lower. The "Enjoyment" factor displayed the biggest qualitative modal differences, with travelers rating commutes by nonmotorized modes to be much more positive on average than those by motorized modes; although, there were many positive outliers for auto drivers.

To investigate other potential determinants, a MIMIC model predicted the four travel affect factors by the same exogenous trip and traveler characteristics as were used to analyze the STS. See Table 3 for significant estimation results of the regressions; full results are available from the author. Model goodness-of-fit statistics varied across the factors: Higher fits were found for the positive constructs ("Enjoyment" $R^2$ = 0.61; "Attentiveness" $R^2$ = 0.47) than for the negative constructs ("Distress" $R^2$ = 0.29; "Fear" $R^2$ = 0.26).

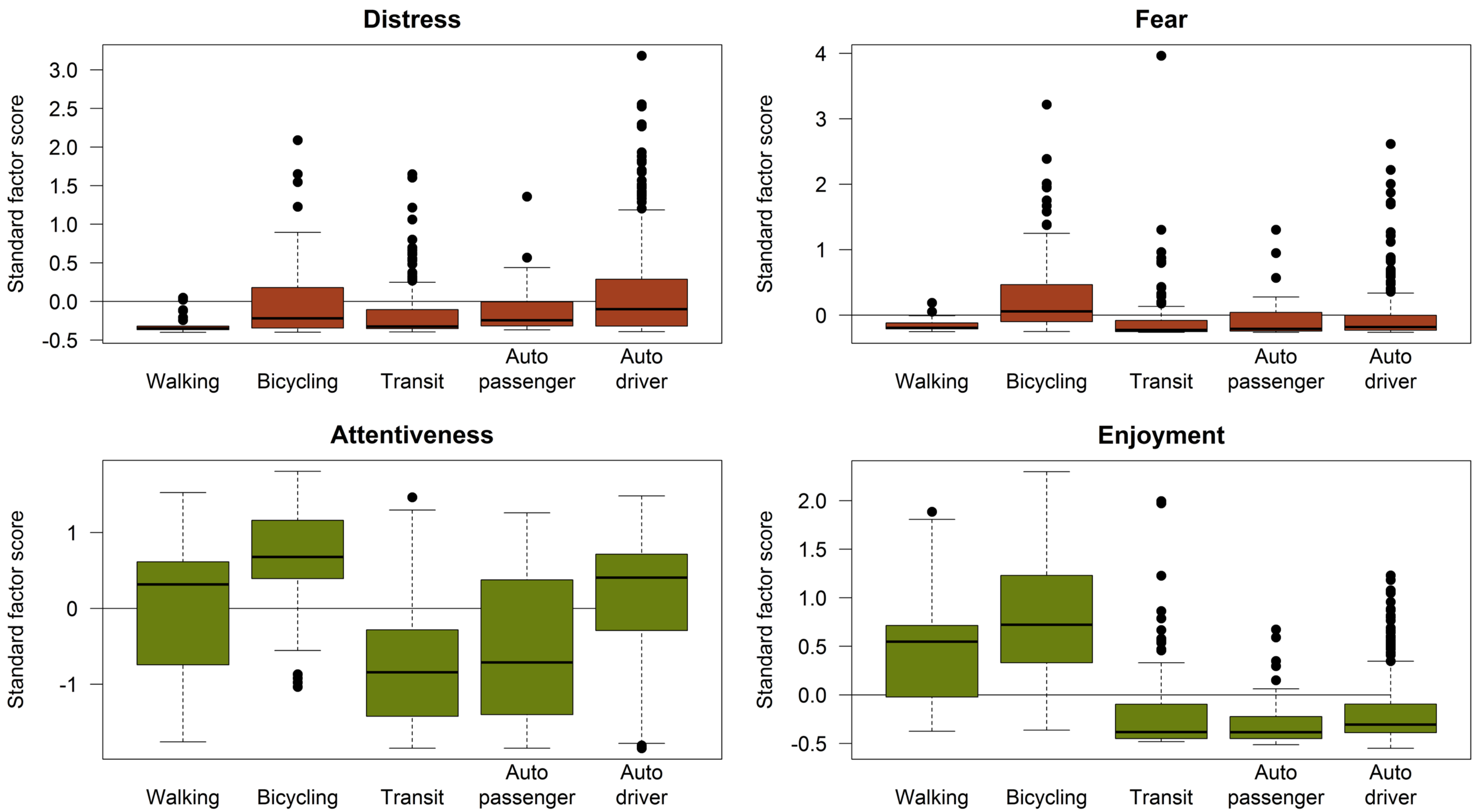


**Figure 3 Box plots of travel affect factor scores by commute mode**

**Table 3 MIMIC model results for travel affect**

| *N = 645* | *Distress* | | *Fear* | | *Attentiveness* | | *Enjoyment* | |
|---|---|---|---|---|---|---|---|---|
| | *B* | *p* | *B* | *p* | *B* | *p* | *B* | *p* |
| *Trip characteristics* | | | | | | | | |
| Mode: Walk | −0.495 | 0.002 * | −0.108 | 0.460 | −0.547 | 0.028 * | 1.061 | 0.001 * |
| Bicycle | 0.108 | 0.491 | 1.152 | 0.000 * | 0.183 | 0.281 | 1.360 | 0.000 * |
| Transit | −0.514 | 0.000 * | −0.148 | 0.238 | −1.320 | 0.000 * | −0.115 | 0.359 |
| Auto, passenger | −0.410 | 0.021 * | 0.132 | 0.530 | −1.129 | 0.000 * | −0.241 | 0.148 |
| Travel time (minutes) | 0.011 | 0.000 * | 0.009 | 0.018 * | 0.003 | 0.383 | 0.003 | 0.345 |
| *Traveler socio-demographics* | | | | | | | | |
| Gender: Female | −0.052 | 0.597 | −0.008 | 0.926 | −0.175 | 0.076 ~ | −0.212 | 0.028 * |
| Race/ethnicity: Hispanic/ non-white/multiple | 0.108 | 0.414 | 0.357 | 0.042 * | 0.079 | 0.529 | 0.192 | 0.167 |
| Education: No degree | 0.095 | 0.463 | -0.057 | 0.690 | 0.241 | 0.090 ~ | 0.021 | 0.871 |
| # children (age ≤ 16) | −0.121 | 0.042 * | 0.000 | 0.996 | −0.069 | 0.240 | −0.014 | 0.809 |
| # seniors (age 65+) | −0.090 | 0.546 | −0.219 | 0.026 * | −0.226 | 0.188 | −0.170 | 0.214 |
| Income: $0–50k | −0.228 | 0.202 | 0.123 | 0.604 | 0.191 | 0.323 | 0.351 | 0.064 ~ |
| Missing | −0.011 | 0.965 | 0.233 | 0.452 | 0.430 | 0.069 ~ | 0.077 | 0.734 |
| Multifamily home | 0.220 | 0.125 | 0.326 | 0.085 ~ | −0.001 | 0.996 | 0.142 | 0.267 |
| # cars | −0.016 | 0.766 | 0.014 | 0.703 | 0.011 | 0.849 | 0.094 | 0.083 ~ |
| *Traveler perceptions* | | | | | | | | |
| Typical travel time: Dissatisfied | 0.358 | 0.000 * | −0.043 | 0.599 | 0.114 | 0.307 | −0.092 | 0.317 |
| Ideal travel time | −0.009 | 0.093 ~ | −0.010 | 0.092 ~ | 0.006 | 0.298 | 0.006 | 0.249 |
| Travel usefulness: | | | | | | | | |
| Mostly wasted | 0.700 | 0.003 * | 0.351 | 0.087 ~ | −0.136 | 0.450 | −0.240 | 0.044 * |
| Somewhat wasted | 0.194 | 0.210 | 0.071 | 0.617 | 0.085 | 0.559 | −0.143 | 0.184 |
| Somewhat useful | −0.033 | 0.760 | −0.057 | 0.691 | 0.196 | 0.169 | 0.072 | 0.483 |
| Mostly useful | −0.155 | 0.197 | −0.359 | 0.030 * | 0.326 | 0.060 ~ | 0.458 | 0.003 * |
| *Model fit statistics ($R^2$)* | | | | | | | | |
| Trip only | 0.146 | | 0.134 | | 0.385 | | 0.509 | |
| Socio-demo only | 0.077 | | 0.112 | | 0.198 | | 0.204 | |
| Perceptions only | 0.176 | | 0.015 | | 0.045 | | 0.319 | |
| $R^2$ overall | 0.293 | | 0.257 | | 0.471 | | 0.612 | |

Statistical significance: * = $p \leq 0.05$, ~ = $p \leq 0.10$.
Variables having coefficients with $p > 0.10$ for all factors are not shown.

Commute mode remained a significant factor after controlling for other trip and traveler characteristics, especially for positive affect. Travel by nonoperating modes (walk, transit, auto passenger) was rated significantly lower on “Distress” than when commuters had to operate a vehicle (bicycle or auto). “Attentiveness” by travelers using the same nonoperating modes was also lower. Bicycle commuters’ high ratings on the “Fear” construct, and nonmotorized travelers’ high levels of “Enjoyment” remained statistically significant. Travel time was positively associated with negative but not with positive emotions. In a model with travel time segmented by mode (not shown), this association appeared to be strongest for transit riders (in both negative constructs) and for auto drivers (only in “Fear”); additionally, other modal effects diminished for negative constructs but did not disappear completely. Nonlinear specifications for travel time were tested but found to be not significant.

Few traveler socio-demographic attributes were consistently or even significantly associated with travel affect. Travelers with more children had lower “Distress” scores, and those

living with a greater number of older adults had lower "Fear" scores. People reporting nonwhite, including mixed, racial/ethnic backgrounds and those living in multifamily housing indicated having higher levels of "Fear" on their commutes. Women were less likely to report positive affect than men. On the positive side, low-income travelers and those owning more cars scored higher on the "Enjoyment" factor.

Travel perceptions were also not strongly or consistently related to travel affect factors. People dissatisfied with their typical commute travel time were more likely to report items of "Distress." On the other hand, commuters whose ideal travel times were longer had lower scores on the two negative affect constructs. Travel usefulness, while not consistently significant, did appear to be associated with travel affect: Commuters viewing their trips as being more useful scored lower on the negative affect constructs and higher on the positive affect constructs.

### *4.3 Travel eudaimonia*

Modal differences appeared when considering the distribution of travel eudaimonia CFA factor scores, as shown by the box-and-whisker plots in Figure 4. On the "Autonomy" factor, modes in which travelers were captive to the decisions of other operators (transit riders and auto passengers) scored lower. Walking and bicycling commuters reported higher levels of "Confidence"; these modes also scored much higher on the "Health" construct. In contrast, modal differences were less pronounced for "Security": Auto travelers ranked slightly higher, and transit riders slightly lower, on average.

A MIMIC model was estimated, using trip and traveler characteristics to predict the four latent variables representing travel eudaimonia. Table 4 presents abbreviated results for significant variables. Fit statistics were not quite as good as for travel affect and the STS, roughly in the one-quarter to one-third range of proportion of variance explained ("Autonomy" $R^2$ = 0.35; "Confidence" $R^2$ = 0.33; "Security" $R^2$ = 0.22). A significant exception was the "Health" construct: The exogenous variables actually explained most of its variance ($R^2$ = 0.74). Note that in this MIMIC model, the modes and the travel usefulness dummy variables had to be collapsed due to empirical identification issues (zero cells).

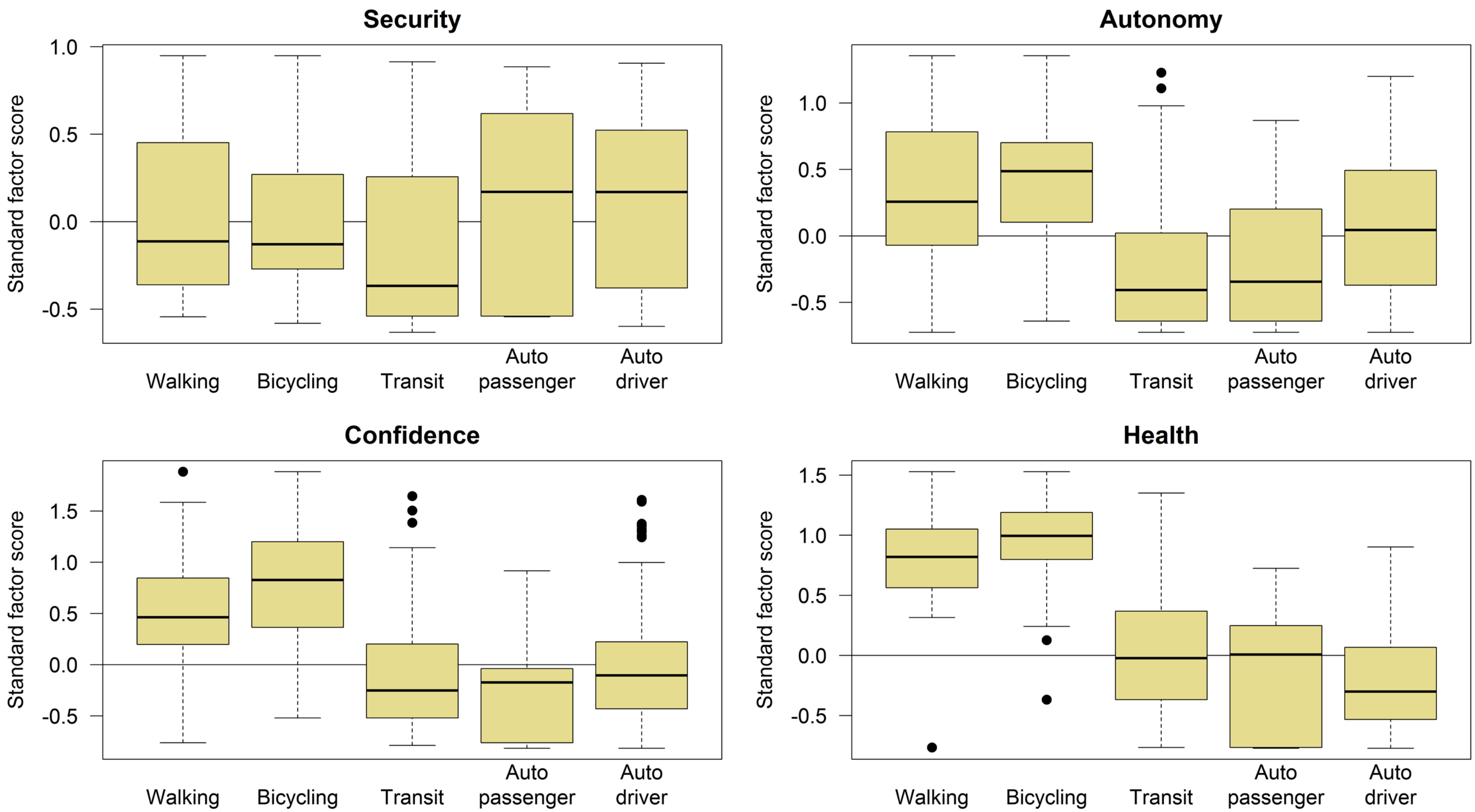


**Figure 4 Box plots of travel eudaimonia factor scores by commute mode**

**Table 4 MIMIC model results for travel eudaimonia**

| *N = 643* | *Security* | | *Autonomy* | | *Confidence* | | *Health* | |
|---|---|---|---|---|---|---|---|---|
| | *B* | *p* | *B* | *p* | *B* | *p* | *B* | *p* |
| *Trip characteristics* | | | | | | | | |
| Mode: Walk/Bicycle | −1.057 | 0.000 * | 0.226 | 0.130 | 0.604 | 0.004 * | 1.441 | 0.000 * |
| Transit | −0.591 | 0.001 * | −0.969 | 0.000 * | −0.080 | 0.718 | 0.391 | 0.001 * |
| Travel time (minutes) | 0.001 | 0.825 | 0.000 | 0.892 | 0.004 | 0.291 | 0.005 | 0.027 * |
| # cotravelers | 0.159 | 0.032 * | −0.009 | 0.884 | −0.057 | 0.606 | 0.048 | 0.302 |
| *Traveler socio-demographics* | | | | | | | | |
| Age: 18–34 years | −0.246 | 0.169 | −0.278 | 0.064 ~ | −0.081 | 0.693 | 0.019 | 0.882 |
| 65+ years | 0.156 | 0.526 | 0.067 | 0.761 | 0.575 | 0.032 * | 0.317 | 0.060 ~ |
| Gender: Female | −0.180 | 0.106 | −0.020 | 0.838 | −0.128 | 0.320 | −0.220 | 0.006 * |
| Race/ethnicity: Hispanic/ non-white/multiple | 0.112 | 0.471 | −0.084 | 0.532 | 0.469 | 0.004 * | 0.134 | 0.202 |
| Education: Grad. deg. | −0.055 | 0.624 | −0.228 | 0.021 * | −0.278 | 0.045 * | −0.120 | 0.175 |
| # seniors (age 65+) | −0.081 | 0.707 | −0.489 | 0.003 * | −0.327 | 0.217 | −0.302 | 0.052 ~ |
| Income: $0–50k | 0.062 | 0.765 | 0.143 | 0.463 | 0.553 | 0.014 * | 0.052 | 0.736 |
| Missing | −0.089 | 0.749 | −0.352 | 0.087 ~ | −0.240 | 0.409 | 0.095 | 0.640 |
| # bicycles | 0.013 | 0.687 | −0.008 | 0.756 | 0.064 | 0.036 * | −0.001 | 0.975 |
| Car-share member | 0.151 | 0.240 | 0.188 | 0.091 ~ | 0.055 | 0.709 | 0.137 | 0.141 |
| Transit pass | −0.006 | 0.957 | 0.006 | 0.954 | −0.111 | 0.425 | −0.176 | 0.054 ~ |
| # hours worked | −0.022 | 0.003 * | −0.004 | 0.486 | −0.009 | 0.305 | −0.002 | 0.667 |
| Flexible work schedule | 0.022 | 0.851 | 0.210 | 0.030 * | 0.038 | 0.791 | 0.026 | 0.753 |
| *Traveler perceptions* | | | | | | | | |
| Typical travel time: Dissatisfied | −0.634 | 0.004 * | −0.168 | 0.122 | −0.014 | 0.929 | −0.250 | 0.010 * |
| Teleportation: No | 0.109 | 0.337 | 0.095 | 0.330 | −0.048 | 0.711 | 0.175 | 0.041 * |
| Travel usefulness: Wasted | −0.177 | 0.264 | −0.155 | 0.251 | −0.076 | 0.704 | −0.236 | 0.039 * |
| Useful | 0.261 | 0.061 ~ | 0.183 | 0.152 | 0.339 | 0.096 ~ | 0.304 | 0.004 * |
| *Model fit statistics ($R^2$)* | | | | | | | | |
| Trip only | 0.086 | | 0.251 | | 0.187 | | 0.671 | |
| Socio-demo only | 0.078 | | 0.156 | | 0.229 | | 0.312 | |
| Perceptions only | 0.028 | | 0.065 | | 0.171 | | 0.453 | |
| $R^2$ overall | 0.216 | | 0.349 | | 0.326 | | 0.739 | |

Statistical significance: * = $p \leq 0.05$, ~ = $p \leq 0.10$.
Variables having coefficients with $p > 0.10$ for all factors are not shown.

As with travel affect, the modal differences identified in the factor score plots of travel eudaimonia remained statistically significant in the MIMIC model. Walk, bicycle, and transit commuters felt significantly less “Secure” than auto commuters. “Autonomy” ratings were significantly lower for transit riders. Nonmotorized modes instilled higher “Confidence” and “Health” scores than did motorized modes, although transit riders reported more healthful commutes than auto travelers. Travel time was a significant and positive factor for only the “Health” construct. A travel time × mode interaction model (not shown) suggested this was mostly a positive association with “Health” of auto travel time; the interaction model also revealed a positive association between “Confidence” and walk/bicycle travel time. To test nonlinear effects, a quadratic travel time term was examined (model not shown); results suggested a minor but statistically significant quadratic (concave down) association between travel time and both “Autonomy” and “Confidence.” Since there was no significant association detected for these

factors when using a linear travel time specification, this finding should be investigated further. Finally, commuters traveling with other people reported feeling more “Secure.”

Some socioeconomic and demographic characteristics of respondents were significantly associated with the various travel eudaimonia constructs. For “Security,” commuters who worked longer hours had lower scores. Younger travelers, those with graduate degrees, and people living with a greater number of older adults had lower ratings for “Autonomy,” while commuters who had flexible work schedules or car-share memberships had higher scores. Older commuters, those reporting nonwhite (or mixed) races or ethnicities, low-income travelers, and people owning more bicycles reported higher levels of “Confidence.” Women, people with transit passes, and those living with older adults reported lower levels of “Health.”

A few traveler perceptions were also related to travel eudaimonia, although these variables explained the smallest proportion of explained variance for all latent variables except “Health.” Commuters dissatisfied with their typical travel times were less likely to report items related to “Security” and “Health.” People who were not inclined to teleport to work were more likely to have high scores on “Health.” The travel usefulness question appeared to have a positive effect on all constructs of travel eudaimonia, although this effect was not significant for “Autonomy.”

# 5 Discussion

## *5.1 Key findings*

### *5.1.1 Modal differences*

The multidimensional nature of the travel SWB constructs in this study helped to illuminate several relevant, cross-cutting, modal distinctions. Notably, there were significant differences between *more physically active modes* (walking and bicycling) and *less physically active modes* (public transit and automobile). Consistent with previous literature, physically active modes received higher scores across multiple constructs. This was apparent for all components of the STS, especially “Positive activation.” Walk and bicycle commutes also rated more than one standard deviation higher on the “Enjoyment” affective factor than did auto or transit commutes. Additionally, these active modes had significantly higher scores on the physical and mental “Health” eudaimonic construct. Overall, these findings are consistent with evidence from a growing health psychology literature on the mental health and well-being benefits of physical activity (Biddle & Mutrie, 2007; Penedo & Dahn, 2005). Physical activity during travel seems to be highly valued (or at least frequently reported) by those who walked and bicycled, and—to a lesser extent—by transit commuters, who may access transit via active modes.

Interestingly, active commuters or potential active commuters (as indicated by a positive association with household bicycle ownership) reported higher levels of “Confidence.” This could indicate interesting but little-discussed benefits of bicycling: feeling adventurous or nonconformist (by using a “novel” or less common mode), exploring one’s environment more closely, or being able to improve one’s sense of self-efficacy.

These active travel mode associations could be partially explained by social desirability or other justification biases: e.g., thinking bicycling should be enjoyable and thus reporting it to be so. Alternatively, they could result in part from factors related to residential location choices: Perhaps people living in places with modal options can choose their preferred modes, while other people who must drive or ride transit (because of longer distances or time constraints) but would prefer to walk or bike cannot and so report more dissatisfaction. Lower levels of well-being for auto and transit modes might reflect this dissonance between travel preferences and travel options; it might also explain some of the negative association with travel time. However, given similar

results for the STS, travel affect, and eudaimonia, these finding suggests that the modal differences—at least in part—likely reflect true well-being benefits from physically active modes.

Another key perspective distinguishes *operating modes* (bicycling, driving)—which require conscious attention to the vehicle navigation task—from *nonoperating modes* (walking, riding transit, and being an auto passenger). Operating modes scored higher on "Attentiveness" and they also had higher levels of "Distress" and lower "Positive deactivation" scores. Although "Attentiveness" is typically about positive affect, in a travel context it may be more negative; in terms of core affect (Russell, 1980, 2003), it may be more about activation than about valence. This suggests that having to operate and navigate a (motorized or nonmotorized) vehicle and interact with other road users can be a stressful task that may degrade well-being. Together, these two modal classifications could help to explain why past literature has found travel well-being to be highest for walking/bicycling and lower for driving (as was found in this study for "Health" and "Cognitive evaluation"): Walking is both a nonoperating and a physically active mode (a positive), while driving is both an operating and a physically inactive mode (a negative). Using multidimensional measures of travel SWB helps to illuminate these distinctions.

Other modal differences were less cross-cutting but are still relevant. The high ratings of "Fear" for bicycle commuters (more than one standard deviation above other modes) likely relate to concerns over traffic safety (from fear of collision and injury) for this *personally exposed mode* (Appleyard & Ferrell, 2017). Given that these are responses for people who actually biked to work, and research suggests that existing bicyclists are more "fearless" (Dill & McNeil, 2016) and that fear of traffic injuries is a strong deterrent to bicycling (Sanders, 2013; Schneider, 2013), this assessment might be even higher in the noncycling population. Similarly, the lower scores for "Security" among nonauto modes could suggest that private motor vehicles (as an *enclosed mode*) offer more safety and privacy, considerations potentially related to the discomfort of interacting with strangers or fears of crime or victimization (Singleton & Wang, 2014). Finally, transit's negative association with "Autonomy" could be due to feelings of being captive to a schedule, route, or operator, with limited flexibility to adapt to changing needs or circumstances. The positive association with work-schedule flexibility supports this interpretation: Commuters with less schedule or time pressure may be able to commute at more desirable times of day or have more modal options from which to choose.

Last, auto commuters on average selected fewer items than did people walking or bicycling. This suggests more consistency in the experiences and/or evaluations of active mode users: Perhaps walk and bicycle commutes are more reliable than driving with respect to travel time and other experiential factors. Conversely, congestion or other negative experiences could generate more variability or less-positive assessments for auto drivers, or maybe the larger sample size of auto commuters naturally captured a wider range of experiences or a more heterogeneous population.

#### *5.1.2 Trip and traveler characteristics*

This study offered some support for previous findings that travel time tends to be negatively associated with travel SWB. Longer trips saw more negative affect ("Fear" and "Distress") and lower scores on two STS constructs. This also suggests that the psychological stresses of commuting (potentially through congestion) or exposure to traffic can build up cumulatively. Studies on physiological commuting stress have documented positive associations between commute duration and levels of cortisol, a stress hormone (Evans & Wener, 2006). Linking physiological and psychological measures of commute stress could be of value.

One notable finding related to traveler characteristics is that women consistently reported lower levels of positive affect, eudaimonia (especially "Health"), and overall hedonic well-being from the commute. This could be a reflection of remaining gendered societal differences in household roles, responsibilities, and divisions of labor (Sarmiento, 1998). For instance, if working women still take on more childcare and/or household maintenance responsibilities than men, they may experience greater time pressure (Bianco & Lawson, 1998) and thus more stressful commutes. This finding could also reflect gender issues associated with residential location choice: Given growing two-worker households and the gender wage gap in the U.S. (Freedman & Kern, 1997; MacDonald, 1999), households on average might better optimize male commutes, leaving women with less optimal commutes. Gender differences in fears over victimization and transportation security (Loukaitou-Sideris & Fink, 2009) could also be influencing women's lower reported travel well-being. The lower scores on "Health" could reflect fewer women choosing active (and thus more healthy and positive) commutes; there remains a significant gender gap in bicycling in Portland (Singleton & Goddard, 2016). Although much remains unexplored, this finding is consistent enough that further research should examine first whether it is purely an artifact of the sample, and (if not), why does it persist?

Interestingly, people of nonwhite (including multiple) races or ethnicities had higher scores for travel "Fear" on average, raising potential equity issues. Perhaps monetary constraints make it more difficult to move into safer, lower-crime neighborhoods; communities of color bear a disproportionate burden of traffic safety issues and unsafe roadways; or people in these circumstances have fewer options to travel by less frightening commute modes. On the other hand, these vulnerable populations may not feel as safe or secure when traveling for more social or societal reasons, such as a fear of victimization or discrimination by law enforcement or immigration authorities (Harris, 1999). In contrast, the "Confidence" construct was positively associated with low-income and nonwhite race/ethnicity variables. This finding remains unexplained and warrants further investigation.

Another repeated finding was the clear positive association between commuters' reports of travel usefulness and their travel well-being, not just for the STS but also for travel affect: More useful trips were also less negative and more positive. Perhaps there is a direct relationship between travel activities and travel experiences, in which people feel more satisfied precisely because they are able to do things and make productive use of their travel time. However, more investigation is needed to examine this potential causal pathway, as a positive association could mean these questions are imperfectly measuring overlapping concepts. For other traveler perceptions, results are also intuitive. The negative associations of travel SWB with travel time dissatisfaction and ideal travel times presumably reflect a reverse directional relationship at a longer temporal scale: People who want longer commutes presumably are satisfied with their typical commutes, so their most recent commute was likely less negative. This suggests a role for the consideration of travel affect in travel behavior choices.

#### *5.1.3 Summary*

Finally, the overall model goodness-of-fit statistics shed light on the relative importance of trip and traveler characteristics for explaining and predicting measures of travel well-being. (This discussion interprets block-specific $R^2$ values as an approximate measure of the relative contribution towards the total explained variance of each group of exogenous variables.) Trip attributes—particularly commute mode—were most explanatory of travel SWB, especially for travel affect and eudaimonia. Traveler perceptions (about travel time satisfaction and travel

usefulness) were moderately useful, depending on the construct, however they contributed the greatest amount of explained variance for the STS. Traveler socio-demographic characteristics performed the weakest, explaining usually less than 20% of latent variable variances, however they were relatively more useful in understanding some constructs of travel affect ("Fear," "Attentiveness") and most constructs of travel eudaimonia.

This discussion confirms the significant role that the transportation experience plays in shaping SWB in the travel domain, particularly due to intrinsic modal differences. If travelers are aware of these modal differences in well-being and have suitable options, they may make mode choices in order to (at least locally, bounded by other constraints) maximize travel SWB, as has been suggested (De Vos & Witlox, 2017; Singleton, 2017). This study is also consistent with other research suggesting an important behavioral role for traveler attitudes and perceptions. More challenging for the study of SWB in the travel domain—and the PUT concept more generally—is the relative lack of explanatory power contributed by socio-demographic characteristics. These traveler attributes are more common, objective, and (usually) easier to assess than perceptions and especially the travel SWB measures that were used in this survey. This result casts doubt that existing methods of data collection (travel surveys with few psychosocial questions) can be used to reliably predict travel well-being in a model. A fundamental shift in data collection efforts and perhaps modeling approaches—to regularly capture and represent socio-psychological factors relevant to travel behavior like attitudes, perceptions, and SWB indicators—is necessary in order to provide for a meaningful study of these connections between transportation and SWB.

### *5.2 Limitations and future work*

The non-representativeness of the sample in some ways limits the generalizability of these results. As noted earlier, the sample included a much smaller proportion of lower-income commuters than would be expected from a random sample. Thus, the results of this study may apply more appropriately to middle- and higher-income commuters. Indeed, lower-income workers may face additional barriers and constraints (e.g., multiple jobs, greater spatial imbalance between home and work) that limit their ability to select a mode to maximize well-being. Nevertheless, as in previous research, income was rarely significant in the MIMIC models, and lower-income travelers actually had higher ratings of "Enjoyment" and "Confidence." Future efforts should examine whether income moderates the relationship between travel mode and SWB.

There are several additional opportunities to improve and extend this work in future research. First, the travel SWB measures could be improved using a more rigorous scale development process, including testing for measurement invariance of the constructs across modes. Second, this study focused solely on commute travel, but there may be different affect structures or symbolic motivations for nonwork travel, including for household maintenance or leisure purposes. Some evidence suggests these trips purposes may be rated more positively than commuting (Mokhtarian & Salomon, 2001).

Other opportunities are available for better understanding factors associated with travel well-being. The "Distress" and "Fear" latent variables appeared to be positively skewed; using nonlinear link functions in the MIMIC model regressions could be a better approach to modeling these constructs and could improve their relatively low $R^2$ values. More fundamentally, unobserved traveler characteristics may be stronger determinants of travel well-being. For example, this study could not control for anticipatory effects, in which thinking about, preparing for, or anticipating (or dreading) activities at the trip destination (work) may have affected travel emotions. On a longer time scale, people with higher overall SWB might also be more likely to

have higher SWB in the travel domain, so it would be useful to control for travelers' satisfaction with life and in the home and work domains. Personality differences could also moderate affective responses to travel. Furthermore, there is evidence that activity participation during travel (travel-based multitasking) may positively influence both positive travel affect and cognitive evaluations of travel satisfaction (Ettema et al., 2012; Rasouli & Timmermans, 2014a, 2014b; Rhee et al., 2013). The significant associations of travel usefulness suggests that this may be true, but there could be better ways to control for it using more distinct concepts. The benefits of travel activities and travel experiences may be difficult to empirically disentangle.

A logical next step is to investigate the extent to which travel SWB affects travel behavior; i.e., that expectations or assessments of travel well-being motivate or influence personal transportation decisions such as mode choice. Indeed, this has been done using this dataset; preliminary results in Singleton (2017) suggest a modest but statistically significant positive association between a second-order "Commute satisfaction" STS construct and mode choice. Investigating the connections between travel SWB and SWB in other life domains—such as job performance and satisfaction with life in general—could also provide important insights. For instance, distancing oneself from work mentally (and physically) during nonwork time (such as the commute) may reduce emotional exhaustion, increase cognitive hedonic SWB, and improve job performance (e.g., Sonnentag, Kuttler, & Fritz, 2010).

### *5.3 Implications and applications*

The relationships and potential determinants of travel SWB identified in these analyses offer implications for transportation planning and policymaking. In particular, specific transportation-related interventions could improve the health and well-being of a population. Active travel modes' high ratings appear to be related to the physical and mental health benefits of exercising while on the commute. Thus, interventions aimed at increasing levels of walking and bicycling—including engineering efforts to make active travel safer and more feasible, such as through protected bike lanes or safer street crossings; and encouragement initiatives to make active travel more fun, friendly, and socially acceptable—might be able to substantially improve SWB for at least a subset of travelers. The high "Fear" experienced by existing bicycle commuters (and that may be deterring potential cyclists) supports the widespread installation of protected bicycle lanes, intersections, and other infrastructure that can mitigate or eliminate stressful roadway conflicts. Additionally, findings suggest that some people are (for many reasons) captive to a particular mode or situation. Offering people more feasible modal options—by providing transit service that facilitates better access to jobs or safer streets and sidewalks upon which to bike and walk, for example—or improving the quality of service of existing modes—whether through more comfortable nonmotorized infrastructure, faster and less crowded transit vehicles, or less congested roadways—could increase travel well-being and decrease emotionally-negative commuting experiences.

Finally, these findings inform our understanding of potential transportation futures. Much has been posited about the travel behavior impacts of fully autonomous vehicles (AVs): how the ability to make productive use of travel time may decrease sensitivities to travel time and cost (reflected in reduced values of travel time savings), increase demand for automobile travel, and potentially offset any operational efficiency or roadway capacity gains obtained from vehicle-to-vehicle and vehicle-to-infrastructure communications (e.g., Childress, Nichols, Charlton, & Coe, 2015). When combined with the information and communications technology innovations that have enabled the expansion of mobility-as-a-service (MaaS) transportation providers (Jittapirom

et al., 2017), AVs may be even more disruptive. For the most part, these discussions have largely ignored potential impacts of AVs and MaaS on travel experiences and well-being (Author, in progress). This study's findings suggest that if auto travelers no longer have to drive and operate a vehicle (and thus, become more like auto passengers or transit riders), they may report lower levels of "Fear" and "Distress" while retaining higher ratings of "Protection." (Although, some people may fear and/or distrust being driven by a stranger or computer.) Reducing the stresses and fears of driving could increase travelers' well-being, which in turn could make auto travel marginally more attractive. On the other hand, travelers whose preferences for high levels of "Attentiveness" and "Freedom" are currently satisfied as drivers may find themselves experiencing more negative SWB in AVs if they no longer have the opportunity to operate a vehicle. Perhaps some of these displaced drivers may turn to bicycling to fulfill such desires.

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