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Modeling travel behavior and sense of place using a structural equation model

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ABSTRACT

Understanding the way in which people conduct their daily activities is the central focus of travel behavior modelers. This often requires an understanding of the way in which people interact with their surroundings. Theorists have paid special attention to the interactions of people and place, specifically the endowment of meaning to places (termed sense of place). This work has a host of applications to explain different facets of behavior. Among these, travel behavior is a prime area for sense of place application due to the constant interaction of land use with transportation. In this paper, we explore relationships and examine sense of place using structural equations and derive six distinct factors representing unique dimensions of sense of place. The data used are from a 719-person survey of two shopping centers in Santa Barbara, California, specifically designed to measure sense of place. The factors extracted represent aspects of attachment – the bond between person and place, dependence – the strength of association between person and place, identity – the individual's identity with respect to place, satisfaction- which corresponds to many of the services offered at each place, atmosphere – such as aesthetics and surrounding ambiance, and community – which highlights the views of the place as being family and kid friendly, or a place with kind or friendly people around. These factors are pilot tested as determinants in behavioral models of mode selection, sequencing of activities, and companionship during activities exhibiting substantial potential of explanatory power. This finding motivates a few additional research directions we outline in this paper.

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1. Introduction

It has been recognized that the interaction between land use and travel behavior is something that must be adequately considered when attempting to describe behavior, build predictive models, and take actions to change behavior. Foundational to the activity based approach of travel demand modeling is the assumption that travel is a derived demand, and is produced by the need or desire to participate in activities in different locations. Understanding the attractive forces that are responsible for the distribution of activities in space is key to deriving accurate predictive and forecasting models. It is important when considering this human-environment interaction to not only consider the physical interaction with place and the economic or need based reasons for that interaction, but also the emotional and affective interactions. These emotional and affective interactions, although harder to measure than attributes such as cost or travel time between two locations, can provide richer explanations for observations in behavior. The rich history of sense of place theory development as well as recent work in quantifying facets of sense of place makes the theory ripe for application to travel behavior research.

The process of travel behavior modeling involves capturing observed variation among people. To do this, researchers often use individual and household attributes to model differences and explain behavior with increasingly finer detail. This detail is needed in many travel demand forecasting model systems that recreate the daily life of households and individuals. In this context, heterogeneous behavior is explained by collecting data about locations that an individual visits, and by recording his or her activities. Econometric models are then estimated using these data, and used to predict the daily whereabouts of people for an entire region (Vovsha et al., 2005; Bradley et al., 2010). Behavioral models often go beyond simple indicators of socio-demographic information in their specification to include attitudes (Kuppam et al., 1999; Sunkanapalli et al., 2000), personality (Prevedouros, 1992), and latent and observed factors of intra-household interaction (Yoon and Goulias, 2010). The inclusion of these types of information creates models with richer detail. Analysts also hope to use these data as travel behavior determinants for specific harder-to-predict facets such as destination choice.

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Among these relatively new types of determinants included in models is *sense of place*. Sense of place researchers have long theorized the emotional connection between people and places and, in more recent research, have attempted to quantify the meaning. The theory of sense of place had its beginnings in the early 1970s. Among those credited with the initialization of the theory was Tuan (1974), who defined it as the "affective ties with the material environment" (p. 93). Many of the early theorists stressed that sense of place was phenomenological in nature. Because of the highly personal and individualized nature, any attempts to quantify this fuzzy concept were considered futile. Although this concept had phenomenological roots, researchers saw the potential of quantifying sense of place (Canter, 1983; Golledge and Stimson, 1997). Several additional concepts related to sense of place were produced as a result of such rich discussions including place identity, which is "the individual's personal identity in relation to the physical environment" (Proshansky, 1978, p. 155), place attachment, which is defined as "the bonding of people to places" (Altman and Low, 1992, p. 2), place dependence, which is defined as the "[person's] perceived strength of association between him- or her-self specific places" (Stokols and Shumaker, 1981, p. 457) and place satisfaction a "the utilitarian value [of a place] to meet certain basic needs" (Guest and Lee, 1983, p. 234).

An evaluation of the scope of research interests can illustrate the scale at which sense of place is studied. For instance, sense of place has been studied as associated with home (Jorgensen and Stedman, 2001, 2006), neighborhoods (Brown and Werner, 2009), in conjunction with physical attributes of the place (Stedman, 2003), at different geographic scales (Shamai, 1991), and with different applications including ecosystem management (Williams and Stewart, 1998), tourism (Brown, 1999; Hallak et al., 2012), place based teaching (Semken and Freeman, 2008), and even association with health care potential (Gesler, 1993). Considerable debate about the psychometric properties of the place-based constructs is still ensuing. Much discussion has centered on the structure of these constructs and the relations between sense of place, place attachment, identity, dependence and others (see Jorgensen and Stedman (2001) for a review of many of these discussions). The existence and nature of these relationships have been statistically examined using structural equation modeling to determine the optimal relationship among these concepts. The research in this paper uses measurement tools and findings from Jorgensen and Stedman (2001). Although there is no uniform agreement on the structure of these place concepts, this work provides theoretical and statistical reference for the investigation of sense of place and related concepts and their influence on behavior. For this reason the estimated factors in this paper should not be considered the last word in the definitions of sense of place constructs. However, we are encouraged by the most recent developments that focus on quantifying sense of place and expressing its facets as factors that we performed in preliminary analysis (Deutsch and Goulias, 2009, 2010).

This work is meant to expand previous work in both sense of place and travel behavior. It explores the potential for sense of place-related explanatory variables in travel behavior models that can be used in simulation, and used to identify urban designs that are both attractive to people and environmentally sustainable. The use of structural equation modeling with latent variables allows us to examine further the structure of measured sense of place by verifying previously identified dimensions and identifying new dimensions. In addition to this, we use several sense of place indicators in travel behavior models to pilot test its worthiness as an explanatory variable. Although some authors have examined specific attributes such as place identity and its relation to destination choices (Zandvliet et al., 2006), we are not aware of any other papers on this subject investigating sense of place in its many dimensions applied to travel behavior. In addition, this cognitive aspect of behavior is still lacking in recognition. For example, Buliung and Kanaroglou (2006) provide a useful GIS toolkit for understanding behavior; however, they do not mention any of the cognitive aspects associated with places. Although spatial and temporal models are important in understanding behavior, there is still an element of behavior that is lacking. In our previous paper (Deutsch and Goulias, 2010) we used answers to attitudinal questions directly as explanatory variables and found them to explain significantly three important travel behavior facets: arrival mode to the shopping center, arrival time at each location, and the location itself. That work did not explore the relationship between the variables used to quantify sense of place, and the underlying latent constructs that are contributing to the observed attitudes, which we attempt in this paper. In addition, in this paper we also attempt to understand the relationship between socio-demographic attributes of an individual and sense of place. Moreover, using structural equations, we bring all these components together in the same covariance matrix and estimate relationships among them.

2. Data description

A sample of 719 persons from an intercept survey conducted at two outdoor shopping centers (malls) in Santa Barbara, California, was used for this analysis. The two malls are within the city of Santa Barbara, both less than a mile and a half from highway 101, which is a major North–South highway between San Francisco and Los Angeles. Both malls are situated along one of Santa Barbara's main arterial streets, State Street, one being downtown and one uptown. Both offer two anchor big box stores, and a variety of smaller retail stores. In addition, both places offer restaurants and additional nearby shopping. Among major differences is the setting, as Paseo Nuevo is situated within the core of the downtown area, and La Cumbre is located in a residential setting. While both malls have additional nearby opportunities, the landscape and surroundings of the two locations are vastly different. Details of the study areas and data collection process and instrument are discussed in Deutsch (2008) and Deutsch and Goulias (2009).

The survey consisted of questions developed to capture the respondents' sense of place views toward each mall. Following work conducted by Jorgensen and Stedman (2001), and Stedman (2003), a series of questions were adapted to this study that focused on the respondents' place attachment, place identity and place dependence. In addition, several additional questions examined other aspects of sense of place. All sense of place questions were asked on a seven-point likert scale ranging from strongly disagree to strongly agree. Additionally, several socioeconomic and demographic questions were included as well as questions about travel behavior before, during, and after the visit to the shopping mall. Because of the intercept format of the survey, travel behavior variables are limited to a small snapshot of the day's activities.

Data collection involved five days of on-site recruitment at each location, conducted during identical time periods. Respondents were asked to fill out a booklet style survey on site, which took on average between 10 and 15 min. Of the 719 respondents, 38.7% were surveyed at Paseo Nuevo and 61.3% at La Cumbre. Of these respondents, 43% are male, 78% are residents of Santa Barbara County and three percent are residents of Ventura County, directly south of Santa Barbara. The respondent pool is of average age of 37 years, with a minimum of 18 years and maximum of 88 years.

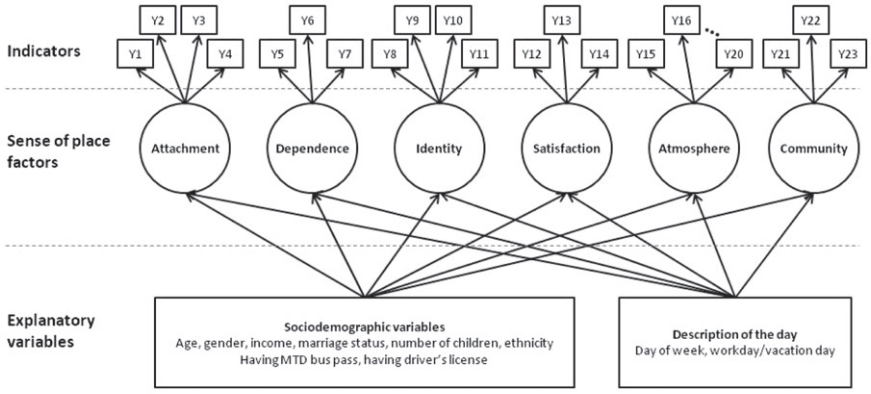
3. Structural equation model

As mentioned, measurement tools, as well as the definition of the structural equation model (SEM), rely heavily on work measur-

ing the three commonly discussed constructs of place identity, place attachment, and place dependence (Jorgensen and Stedman, 2001). In this work, the researchers find that both a tripartite model of the three aforementioned constructs, as well as a higher level model of the three constructs with a higher order construct of sense of place, are models that fit similarly (indicated by fit statistics). For the purposes of this paper, we chose to use the framework provided by the tripartite model, as we are including several additional regression paths to explain each construct (see Fig. 1). In addition to the three previously discussed constructs, three additional constructs of sense of place are developed in this analysis (further details of the estimation follow). The additional constructs are based on questions relating to one's satisfaction with the place, a construct of sense of place previously developed but not as widely known (Stedman, 2003), as well as questions about the physical/aesthetic surroundings of the place and the social environment. Researchers have discussed the importance of physical, social, and cultural attributes of place in developing a sense of place (Shumaker and Taylor, 1983; Sack, 1997). The inclusion of these indicators in a factor analysis provides insight to how these concepts manifest themselves in everyday activity locations, and which place attributes are more apparent in everyday settings. In addition to this, development of a structural equation model allows us to identify indicators that we hypothesize (and test) explain different types of sense of place attitudes among individuals. These include socio-demographic attributes such as gender, age, and others. Time of day at which the respondent visited the location is also hypothesized to influence observed sense of place. The conceptual model capturing the relationships among the different sense of place constructs, attitudinal variables used to create them, and explanatory variables of their variation used in this paper are reported in Fig. 1. The observed variables Y1 to Y23 are also reported and are measured using Likert scores (coded from −3 for strongly disagree to 3 for strongly agreeing) to the questions/statements listed in Fig. 1.

To develop the SEM, latent sense of place factors were identified using exploratory factor analysis (EFA). As mentioned, the analysis included additional sense of place questions other than those used by Stedman (2003) for attachment, dependence and identity, which were considered to be predefined factors in the final SEM. Our intention here is to replicate the experience of one successful attempt to quantify sense of place and build additional dimensions that are likely to correlate well with travel behavior. In order to identify additional factors, EFA was conducted with the indicators not belonging to the attachment, dependence and identity factors. Through an iterative process of eliminating cross loading indicators and evaluation of fit indices, a final factor structure was obtained. After comparing a series of models containing different numbers of factors, and excluding non-salient indicators, the results indicated that a model of three additional factors was most appropriate. The three additional sense of place factors are labeled as: satisfaction, atmosphere, and community.

In the second step, the six factors (attachment, dependence, identity, satisfaction, atmosphere, and community) are put in the final form of SEM, and explanatory variables are included in the model in addition to the structure found from the factor analysis. The model structure is provided in Fig. 1, and consists of three tiers: explanatory variables, latent sense of place factors, and factor indicators (or sense of place questions). Each factor is measured by three to six indicators and the factors are explained by socio-demographic variables and characteristics of the day.



Y1 - [Place] Makes me feel relaxed	Y12- I am satisfied with the food
Y2 - [Place] Makes me feel happy	Y13- I am satisfied with the products offered
Y3 - I Would be disappointed if [Place] did not exist	Y14- I am satisfied with the entertainment options
Y4 - One of my favorite places in Santa Barbara	Y15- Visually appealing architecture
Y5 - Meets my needs better than any other location	Y16- Peaceful and relaxing atmosphere
Y6 - Has better diversity than any other place	Y17- Beautiful mall
Y7- I only come for a specific reason	Y18- Good bal. of decorative features & businesses
Y8 - Reflects the type of person I am	Y19- Has artistic value
Y9 - Says little about me (inverted)	Y20- Reflects the culture of Santa Barbara
Y10- Makes me feel like I can be myself	Y21 - [Place] is family friendly
Y11- Good reflection of my identity	Y22- [Place] Kid friendly
	Y23- [Place] has friendly people around
Note: All variables are coded from -3 for strongly disagree to 3 for strongly agree	

Fig. 1. Sense of place factor model structure.

This three-tiered structure can be specified by combining the latent variable model (Eq. (1)) and measurement model (Eq. (2)).

$$\eta = \beta\eta + \Gamma\xi + \zeta \tag{1}$$

$$y = \Lambda_y\eta + \epsilon \tag{2}$$

$$x = \Lambda_x\xi + \delta$$

p is the number of sense of place indicators; q is number of explanatory variables; m is number of sense of place factors; n is number of explanatory factors; y is $p \times 1$ column vector of sense of place indicators; x is $q \times 1$ column vector of explanatory variables; η is $m \times 1$ column vector of latent sense of place factors; ξ is $n \times 1$ column vector of latent explanatory variables; Λ_y is $p \times m$ coefficient matrix of the relation of y to η; Λ_x is $q \times n$ coefficient matrix of the relation of x to ξ; ε is $p \times 1$ error term of y; δ is the $q \times 1$ error term of x.

By the model structure of Fig. 1, the following conditions hold:

$$x = \xi \tag{3}$$

$$B = 0$$

The model structure illustrated in Fig. 1 assumes a three-tiered structure, where the explanatory variables (x) directly impact endogenous factors (η) without the intermediate explanatory latent factor (ξ). When we set x and ξ equal we reduce the four tiers into three to accommodate the model structure. In addition, this structure is intended to examine the relationship among the explanatory variables, factors and indicators and not on any causal relationship among the factors and we can set $B = 0$.

Therefore, the general model of Eq. (1) reduces to the following form (Eq. (4)). This reduced model was estimated using M-plus software (Joreskog and Goldberger, 1975; Muthén and Muthén, 2010).

$$\begin{aligned} \eta &= \Gamma x + \zeta \\ y &= \Lambda_y\eta + \epsilon \end{aligned} \tag{4}$$

Two sub-sample groups were defined in the model (Paseo Nuevo: $n = 278$, La Cumbre: $n = 441$). Coefficients between the latent factors and the indicators are assumed to be identical for each location (assuming sense of place factors are measured in the same way in the two groups of mall visitors). In this approach the model is measuring the way in which an individual relates to the questions targeting aspects of sense of place, not how the questions measure sense of place at each location.

To accommodate continuous factors and ordered discrete indicators, a WLSMV (weighted least squares with a corrected mean and variance) estimator was used (Muthén et al., 1997).

4. Model results and discussion

4.1. Model fit

Goodness of fit statistics for the resulting SEM using a WLSMV estimator are provided in Table 1. Evaluation guidelines from Hu and Bentler (1999) were followed. Good model fit criteria include Standardized Root Mean Square Residual (SRMR) values .08 or below, Root Mean Square Error of Approximation (RMSEA) values .06 or below, and Comparative Fit Index (CFI) values .95 or greater (Hu and Bentler, 1999). There are a few points to be noted in interpreting the goodness of fit of this model. First, it is important to note that due to the specific estimator used, the degrees of freedom of the final model is calculated during the estimation and as a result a chi squared comparison of differences cannot be used to test the baseline model with the final model. Instead, an evaluation of the p-value of the model (derived from the degrees of freedom and the chi square value) can indicate goodness of fit (Bentler and Bonett, 1980). Another important consideration is that the chi-square value is sensitive to sample size, and large samples easily return statistically significant chi-square values ($p < 0.05$). Considering the relatively large sample size of this study ($n = 719$), and the CFI, Tucker Lewis Index (TLI), and RMSEA values, the fit statistics indicate grounds to accept the suggested model to explain the relationship between sense of place questions, latent sense of place factors, and explanatory variables.

Table 1
Structural equation model goodness of fit.

	Chi square value	Degrees of freedom
Chi-square test of model fit for the baseline model	6199.001*	137
Chi-square test of model fit	547.928*	225
Goodness of fit statistics	CFI = 0.947, TLI = 0.968	
Root Mean Square Error Of Approximation (RMSEA)	0.063	

* p Value = .00.

Table 2
Sense of place factors.

Sense of place factor	Indicator	Estimates	S.E.	Est./S.E
Attachment	Makes me feel relaxed	1	0	0
	Makes me feel happy	1.131	0.04	28.155
	Would be disappointed if it did not exist	0.881	0.043	20.355
	One of my favorite places in Santa Barbara	1.052	0.042	24.869
Dependence	Meets my needs better than any other location	1	0	0
	Has better diversity than any other place	1.053	0.051	20.486
	I only come for a specific reason	0.639	0.059	10.91
Identity	Reflects the type of person I am	1	0	0
	Says little about me (inverted)	0.676	0.044	15.368
	Makes me feel like I can be myself	0.793	0.041	19.153
	Good reflection of my identity	1.029	0.039	26.471
Satisfaction	I am satisfied with the food	1	0	0
	I am satisfied with the products offered	1.058	0.079	13.314
	I am satisfied with the entertainment options	0.935	0.072	12.97
Atmosphere	Visually appealing architecture	1	0	0
	Peaceful and relaxing atmosphere	1.042	0.048	21.919
	Beautiful mall	1.084	0.044	24.595
	Good balance of decorative features and businesses	1.115	0.046	24.072
	Has artistic value	1.028	0.042	24.44
	Reflects the culture of Santa Barbara	0.965	0.046	21.096
Community-oriented	Family friendly	1	0	0
	Kid friendly	0.879	0.039	22.588
	Friendly people around	1.011	0.048	21.055

Note: S.E. is estimated standard error.

4.2. Factor structure

Table 2 provides the coefficient estimates for sense of place questions (indicators) and the factors. As shown, each indicator

significantly loads into a meaningful sense of place factor. This shows that the same set of questions can be used to obtain sense of place meaning at two different locations.

The first three factors (attachment, dependence and identity) were imposed upon the model structure as previously mentioned. The questions for these factors loaded on the factors with high significance. The three additional EFA factors represent place satisfaction, which corresponds to many of the services offered at each place, the atmosphere of the place such as aesthetics and surrounding ambiance, and the community oriented nature of the place, which highlights the views of the place as being family and kid friendly, or a place with kind or friendly people around.

The estimated coefficients show how each discrete indicator is scaled into the continuous factor that it is related to. The coefficient for the first question of each factor is fixed as 1 as reference and the relative scales of all the other indicators and their significances are listed in Table 2. Since the relationship between the factors and the indicators was defined according to the result of an exploratory factor analysis, all the indicators are significant measures of the factors.

4.3. Impact of socio-demographics and day information

The next portion of the structural equation model estimated the impact of socio-demographic variables and information about the day of interview on the factors. The estimated parameters are listed in Table 3, and there are several variables that were found to be significant in explaining sense of place views. Table 3 shows that sense of place factors are differently affected by socio-demographic variables at the two malls. This result explains how each socio-demographic sub-group has a different sense of place at each of the two malls. For the attachment factor, marital status and income have significant impacts at Paseo Nuevo, and gender and marital status have significant impacts at La Cumbre. Interestingly, the variable representing being married/domestic partner) has significant impacts but with opposite signs (0.276 at La Cumbre and −0.394 at Paseo Nuevo), implying that the level of attachment at the two malls is very different for married people than for other groups. Similar interpretation about the results can be attributed to each of the other five sense of place factors and the significant variables. Equally important is also the lack of significance for some of these variables showing similar sense of place attitudes among respondents. For instance, age is not significant for attachment or identity, indicating that similar attitudes can be found across different age cohorts. Additionally, having an MTD bus pass is only significant (with a negative impact) for La Cumbre satisfaction. This is perhaps due to the lack of access by bus to this shopping center, and owning a bus pass only matters for this one dimension. To explain observed differences, Figs. 2 and 3 display the distribution of the satisfaction factor for males and females at La Cumbre (LC) and Paseo Nuevo (PN). The difference in distribution for different sub-groups offers insight to why sense of place factors can be potentially significant explanatory variables of travel behavior by explaining the variability of the emotional and psychological interaction between built environment and individuals in multiple dimensions, which is not fully explained only by socio-demographic variables.

These distributions show the large differences between locations and between men and women in scores in the satisfaction factor. Women at La Cumbre follow a trend similar to normal that is centered around −1, while men tend to have a more concentrated factor score from a little less than −1 to 0. This also indicates that while the genders have different distributions, they are both centered slightly negatively. However, this is not the case for satisfaction at Paseo Nuevo, as both men and women score higher. The distributions for men and women are also not as drastically different for Paseo Nuevo as they are for La Cumbre. Other variables found to be significant in explaining one or more factors included different age, income, and ethnicity dummy, as well as presence of a driver's license and marital status. It should be noted, however, that although most of these variables were significant in at least one portion of the model, there were not enough significant variables to predict confidently sense of place using socio-demographics. This makes a case for the inclusion of both socio-demographic and sense of place information in behavioral models, which are discussed further in following sections.

4.4. Travel behavior and sense of place

In addition to the structural equation model of sense of place, the resulting factor scores were used in an analysis of several attributes of behavior. Multinomial logit models were estimated using the dependent variables of mode (car, walk, all other), sequencing of activities before and after (home-mall-home, home-mall-work, home-mall-other, work-mall-work, work-mall-home, work-mall-other, other-mall-home, other-mall-other and other-mall-work), and companionship (alone, spouse, other family, friends) during the visit to the mall. Models were developed using a stepwise process of entering (or replacing) additional variables of a common type to the model. We employ this method to develop these specifications for six models in several steps. For example, model development followed a procedure where step 1 includes only socio-demographic explanatory variables and day information, step 2 includes the variables of step 1 and location, and step three includes the variables of step 2 and sense of place factors in continuous form. In this way we obtain nested specification models and we can compare them using chi-square statistics of the log-likelihood ratio. Table 3 provides both the specifications of variables added or omitted, and the resulting goodness of fit measures of these hierarchically specified models. Variable types entered using this procedure include socio-demographics, details about the day of the respondent's visit (day of week, respondent work day, vacation day), a dummy for the location (Paseo Nuevo or La Cumbre), and sense of place factors (both in continuous and discrete form of equal quintiles). Prior to this step, the continuous factors were broken into different numbers of even-sized discrete classes to find a good way to represent the sense of place factors in a discrete form. Fewer than four classes were not able to capture the heterogeneity of the sense of place factor across individuals, and the models with five classes were selected out of the models with four or more discrete classes based on their parsimony and the power of explanation. Testing discrete settings of sense of place factors against the original continuous setting is used to detect non-linear or even non-ordinal effects. It is also used to see if the power of explanation is enhanced when non-linear or non-ordinal types of effects are considered, although the discrete settings potentially undermine the parsimony of the models.

A comparison of model fit indicators across different model settings is given in Table 4 and a discussion about the results is given in the next sections.

4.5. Location and sense of place

First, the change in chi square for the model of mode is much more drastic with the addition of the location dummy variable (mode model 1 compared with model 2) than for the inclusion of sense of place factors (mode model 1 compared with model 3 or model 5), while the use of degrees of freedom is less. This change in chi-square is likely due to the fact that there are many additional location differences such as physical characteristics (availability of parking, downtown vs. suburban location, accessibility, relative distances to other destinations) that are not included in the model,

Table 3
Impact of Socio-Demographic Characteristics on Factors.

Sense of place factor	Attachment		Dependence		Identity		Satisfaction		Atmosphere		Community-oriented	
Location	PN	LC	PN	LC	PN	LC	PN	LC	PN	LC	PN	LC
Explanatory variables												
Gender												
Female		0.166*	0.220		0.280*	0.320**	0.255*	−0.213*	0.228*			
Age												
(base: unknown)												
18–24			−0.753									
25–29			−0.982*	−0.462					−0.768			
30–39			−0.838*	−0.438				−0.427*				
40–65			−0.933**							−0.399		
66+												
Marriage status												
(base: all the other)												
Married or domestic partnered	−0.394	0.276*										
Single												
Income												
(base: unknown)												
Low	−0.454*											
Medium	−0.424								−0.444			
High				−0.538**								
Day of week												
(base: Sunday)												
Monday												
Wednesday												
Friday												
Saturday				−0.295*								
Ethnicity												
(base: all the other)												
Asian			0.463						0.426			
Hispanic												
White			0.304				0.371*		0.364*			
MTD (Public Transit) pass												
Has an MTD pass								−0.281*				
Driver's license												
Has a driver's license			0.273						0.274			

Note: insignificant total effects are not listed.
* Significant at the 5% level (*).
** Significant at the 1% level (**), and the rest are marginally significant at the 10% level.

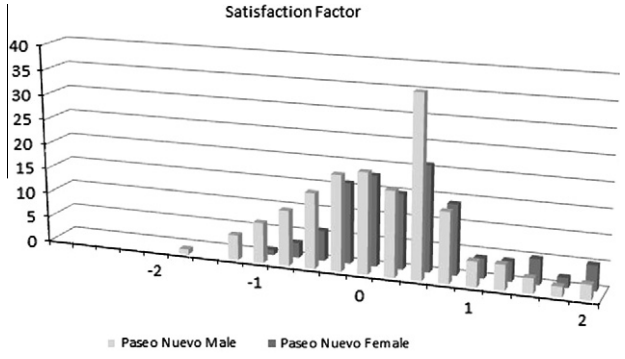


Fig. 2. Paseo Nuevo satisfaction factor scores.

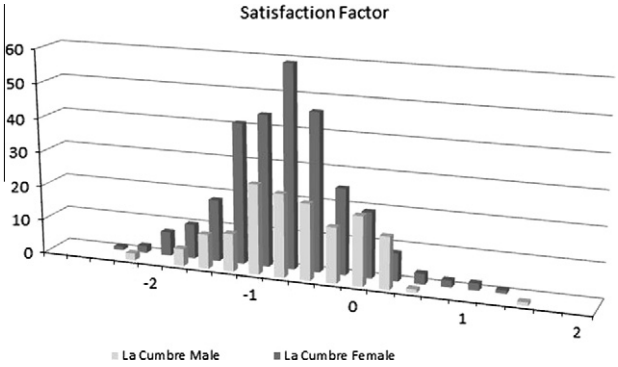


Fig. 3. La Cumbre satisfaction factor scores.

which impact the mode that is used. The inclusion of sense of place information combined with physical attributes of the places brings attention to a direction for future work, discussed further in the next section. Additionally, sense of place questions about transportation (such as safety when walking, and views toward parking), were not included in this factor model. This is largely because they could not be associated with any of the sense of place factors defined here, and were not sufficient to form a separate sense of place factor. In future models, separate indicators to determine whether these variables provide valuable explanation can be included. It is important to note, however, that this trend with the location variable is only "important" for the model of mode, the other two models with the same change in degrees of freedom showed much less drastic changes in chi squared values.

When both sense of place factors and the location variable were included in the same model (models 4 and 6 for each of the three behavioral variables tested), there was only slight improvement in the chi-square. This is perhaps due to the fact that there is an excess of redundant information contained in the model when both are included in the specification (said in a different way, the model is suffering from multicolinearity). Another aspect to note when examining all the measures of model fit is the inclusion of non-sig-

Table 4
Model comparisons.

Model number	Variables entered				−2 Log likelihood		Likelihood ratio test		Nagelkerke *R*-square
	Soc/dem	Day	Loc	Sense of place	Intercept only	Final	Chi-square	d.f.	
Mode									
1	*	*			709	584	124.9	32	0.213
2	*	*	*		826	584	242.0	34	0.382
3	*	*		*(Quintiles)	988	752	236.1	80	0.374
4	*	*	*	*(Quintiles)	989	692	296.7	82	0.452
5	*	*		*(Cont.)	990	795	195.7	44	0.319
6	*	*	*	*(Cont.)	990	735	255.1	46	0.400
Sequence									
1	*	*			1706	1544	162.6	64	0.211
2	*	*	*		1884	1709	175.1	68	0.226
3	*	*		*(Quintiles)	2274	2004	269.7	160	0.327
4	*	*	*	*(Quintiles)	2275	1999	276.1	164	0.333
5	*	*		*(Cont.)	2277	2080	196.3	88	0.249
6	*	*	*	*(Cont.)	2277	2073	203.8	92	0.258
Companion									
1	*	*			1600	1223	377.5	64	0.433
2	*	*	*		1750	1361	388.7	68	0.443
3	*	*		*(quintiles)	2061	1589	472.0	160	0.515
4	*	*	*	*(quintiles)	2061	1577	483.7	164	0.519
5	*	*		* (cont.)	2064	1654	409.6	88	0.460
6	*	*	*	*(cont.)	2064	1644	420.1	92	0.469

Quintiles = category form of factors, cont. = continuous sense of place variable of factors.

nificant variables in each model that might be hurting the overall model fit. Insignificant variables were kept in each model for a more direct comparison between nested models and variable types.

Finally, it is important to recognize that while the degrees of freedom are only increased by 2 with the inclusion of a location dummy in this model, this would not be the case in a full location or destination choice model. Each location included in the model would require a separate indicator, thereby significantly increasing the required degrees of freedom. If location and sense of place can each be used to capture a portion of similar information, using sense of place factors has the potential to provide a more computationally preferable model with better explanation of the mechanism behind behavior patterns at different locations.

4.6. Discrete vs. continuous sense of place factor indicators

Models using sense of place were developed including both discrete forms of the factors of five equal quintiles, and their continuous counterparts. Determination of the optimal way to represent the factors in discrete form was data driven, by examining the distribution of the factors. By breaking factor scores into equal quintiles (very high scoring a 5 and very low scoring a 1), we were able to test if non-linear or non-ordinal effects exist in sense of place factors as explained previously. However, the added benefit of a more detailed understanding was also met with a higher consumption of degrees of freedom, as we were entering 4 categories (excluding one category as the baseline) for each of the six factors, a total of 24 variables. Results of model fit comparisons indicate that the use of "discretized" sense of place factor variables does not enhance the models' descriptive power enough to warrant the addition of so many variables. Although continuous and discrete sense of place factor variables provide similar interpretation in general and we selected a continuous representation over the discrete sense of place factor variables in this context, discrete factor variables do show a few significant patterns that the continuous forms do not capture. For example, a negative association between the lowest level of identity and the propensity to walk to a mall and a positive association between the lowest level of dependency and the propensity to go to a mall alone. These types

Table 5
Significant continuous sense of place factors.

	Attachment	Dependence	Identity	Satisfaction	Atmosphere	Community
Mode						
Walk	−1.157*				1.156	
Car		−0.740	0.621*	−0.586*		
Sequence						
HMH			0.644			
HMO		−0.609*				
OMH			0.706			
OMO			0.629	0.528*		
Companion						
Alone					0.809	
Spouse						
Family (other)						
Friend						

* Marginally significant, $0.05 < p < 0.1$.

of effects have to be considered somehow in behavioral models, which is an important task for future research.

Results of models using continuous factors are provided (Table 5) with significant sense of place factors in each model and significance level. As reported, several sense of place factors impact the outcome of the dependent variable. Of note, the use of a car is marked by lower place dependence and satisfaction, but higher place identity. Additionally, higher scoring in the atmosphere factor significantly predicts walking more than other modes. The classic chicken-and- egg in causality problem is apparent here, as we are unable to determine whether those who are predisposed to the atmosphere choose to walk, or those who walk take notice and view the surrounding atmosphere more positively. Regardless, the walkers tend to have a lower attachment score as well. This might be because the walkers walk to the shopping mall because it is close to where they live or work. Once a person has the ability to drive, he or she might be able to choose a location that has a higher attachment level. Atmosphere was again significant for those who have no companion for their visit, perhaps again indicative of either those who are alone enjoying the atmosphere more because they can take it in more easily, or those who decided to come to the mall alone because they were drawn by the atmosphere. Interestingly, only one factor is significant in the model of companionship, and community does not influence any of the three behavioral variables. This result can have many explanations, and requires further investigation. The fact that a person is traveling with others might explain a lower sense of place, because the trip involves the needs and desires of others. The impact of other individuals and their sense of place on the decision of destination cannot be examined with these data, but will be investigated in future studies.

5. Conclusion

The research presented in this paper examines the structure of sense of place and how it can be measured using a set of survey questions as well as its use in travel behavior models. In this context, sense of place factors were extracted using a three-tiered, structural equation model, which simultaneously estimated six sense of place factors: attachment, dependence, and identity, as well as satisfaction, atmosphere, and community. Through this research we have been able to both transfer successful questions measuring well accepted sense of place constructs and examine further place attributes contributing to sense of place. However, it is necessary to further this research and the preliminary findings of this exploratory analysis. All six factors need to be verified in future studies for their ability to explain behavior, and should be examined in different everyday activity settings to compare the strength of the manifested factors across types of activities and settings. In parallel, qualitative analysis can be used to enhance the understanding of these concepts (Deutsch and Goulias, 2012).

In addition, as mentioned in the beginning of this paper we were able to identify the correlation between each factor and socio-demographic indicators that explain their variation in the sample used in this paper. Interesting findings include gender as the only explanatory variable for Identity, while dependence varies significantly across age groups, income levels, and ethnicity. Additionally, the sample of the survey is split into sub-samples based on the location at which persons were surveyed to enable comparisons of contexts between groups of people. Although several socio-demographic characteristics were shown to be significant in explaining sense of place attitudes, these indicators are only able to explain a small subset of the variation, and the rich nature of sense of place may require more in-depth scrutiny of their formation as well as other determinants. This study is limited to sense of place about two specific locations studied, and within a short period of a day's activities. Future research should be conducted to determine if there are aspects of sense of place attitudes and their development that might be predicted more completely using socio-demographic indicators.

Sense of place factors were then entered as indicators to explain activity-travel behavior (mode, sequence of activities, and companionship). Models were developed using sense of place factors in both continuous and discrete form. Comparisons showed that while factors in discrete form offer more explanation of each sense of place factor, they did not improve the model fit enough considering the loss of degrees of freedom. Finally, models comparing the use of a dummy for location and sense of place information provided some interesting results, which offer additional possibilities for future directions. Results indicate that sense of place information does not perform better than a binary indicator for place when explaining mode, indicating that substantial place-based information may not represented in the subset of sense of place questions analyzed. This includes accessibility such as transit service or availability of parking, and physical attributes such as walkability. These aspects of transportation facility and services, although used quite frequently in transportation research, have never been combined with sense of place information and would not be possible in this study because only two places were analyzed.

This preliminary research indicates that the use of attitudes and measured place characteristics offer great promise in model improvement. The development of models of travel behavior and land use require the accurate representation of decision making. This has largely been based on an economic realism of the choice process, but should also include a psychological element. The emotional relationship of a person to a place is naturally engaged the decision making process. This emotional relationship is developed through interaction and experience with the physical place as well as the characteristics inherent to the place. As Lynch (1960) points out convincingly, physical characteristics give humans cues of how to interpret a landscape, or what he terms imageability. This imageability is at the crux of the physical and psychological nature of place, and aids in creating this meaning, sense of place. Deeper investigation into how humans interpret physical attributes and cues and translate them into meaning can offer great advances to both our planning practices and travel behavior models. Using knowledge of sense of place and how people interpret meaning from physical cues of landscapes is useful for numerous domains. Although similar concepts to sense of place have been applied under different contexts, this has never been done with the goal of bridging land use, planning, and transportation practices. Through this analysis, it is evident that there are several aspects of sense of place that evoke differing meaning from individuals. Using knowledge of how different sense of place attitudes are developed, and equally importantly by whom these sense of place attitudes are developed, can provide transportation planners with knowledge to plan more sustainably. Sense of place attitudes offer further insight into why people are traveling to the places they are. As seen in this analysis, travel to malls goes beyond the material goods offered, and elicits emotional connections. Given this finding, attracting people to specific places can be done through developing both a variety of attractive activity options and an accompanying positive sense of place. Attracting people from the right geographic locations, and building more attractive, meaningful and relatable places closer to home can reduce vehicle miles traveled and promote more sustainable mode usage. A more formal approach to understanding the way in which these spaces are endowed with meaning and an incorporation of the sense of place development process into planning is worth considering. Although this research is in its early development stages, it has promise for future data collection, modeling, and planning practice.

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