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What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods?

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Abstract

The academic literature on the impact of urban form on travel behavior has increasingly recognized that residential location choice and travel choices may be interconnected. We contribute to the understanding of this interrelation by studying to what extent commute mode choice differs by residential neighborhood and by neighborhood type dissonance—the mismatch between a commuter's current neighborhood type and her preferences regarding physical attributes of the residential neighborhood. Using data from the San Francisco Bay Area, we find that neighborhood type dissonance is statistically significantly associated with commute mode choice: dissonant urban residents are more likely to commute by private vehicle than consonant urbanites but not quite as likely as true suburbanites. However, differences between neighborhoods tend to be larger than between consonant and dissonant residents within a neighborhood. Physical neighborhood structure thus appears to have an autonomous impact on commute mode choice. The analysis also shows that the impact of neighborhood type dissonance interacts with that of commuters' beliefs about automobile use, suggesting that these are to be reckoned with when studying the joint choices of residential location and commute mode.

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Keywords: Residential location; Multinomial logit; Commute mode choice; Built environment; Residential self-selection

1. Introduction

In the USA and Europe land use based solutions to transportation problems have rapidly gained in popularity over the past decade. The principles of New Urbanism (in the USA) or the Compact City (Europe) have found a solid place in the profession's thinking. This popularity is not least the result of numerous empirical studies demonstrating that living in higher density, mixed use neighborhoods is associated with less car

use compared to living in low density, suburban environments (for example, Frank and Pivo, 1994; Næss et al., 1995).

The academic literature is, however, equivocal about the effect of neighborhood characteristics on reducing car use in general and for commuting in particular. It is not completely clear, for instance, how important land use characteristics are in the explanation of commute behavior. While urban form dimensions at the neighborhood level affect commute mode choice or commute length (Cervero, 1996a, 2002), other variables appear to be more important. This is particularly true for sociodemographic factors, such as gender, household composition, and income. However, travel-related attitudes or lifestyle variables may also be more important. Although not specifically focusing on commute travel,

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Kitamura et al. (1997) found that attitudes are more strongly associated with travel than are land use characteristics.

In addition, the relationship between urban form and commute behavior may not be a direct one. Recently a number of authors have claimed that residential location choice is not exogenous to the association between land use variables and travel behavior (Boarnet and Crane, 2001; Cervero and Duncan, 2002; Handy, 1996; Sermons and Seredich, 2001; Srinivasan and Ferreira, 2002; Van Wee et al., 2003). They argue that a household with a predisposition toward a certain type of travel “self-selects” a residential location enabling the pursuit of that preferred type of travel. For example, households whose members prefer to travel by public transit choose to reside for that very reason in a location providing easy access to transit infrastructure. If this is true, the commonly observed correlations between land use configuration and travel behavior do not so much reflect direct causality but complex relationships of these factors with others, such as attitudes toward travel. This suggests a need for studies of the interdependence of different types of residential locations, commute behavior characteristics, and attitudes toward travel and land use. To the best of our knowledge little work has thus far been done on this subject.

This paper is positioned in a series of studies designed to enhance our understanding of the complex relationships among residential location, commute behavior, and attitudes toward travel and land use. We focus on the concept of residential neighborhood type dissonance, or mismatch between preferred and actual type of residential location, as a way to assess the comparative roles of the built environment and residential self-selection in travel behavior choices. Our basic question is simple: do mismatched individuals travel more like the matched residents of the neighborhood they *actually live in*, or more like the matched residents of the kind of neighborhood they *prefer to live in*? The former outcome suggests that the effects of the built environment outweigh personal predispositions; the latter outcome suggests the converse.

Schwanen and Mokhtarian (submitted for publication) begins this series of studies by exploring the role of attitudes toward travel and land use in residential location choice. In Schwanen and Mokhtarian (2004), we model dissonance itself as a function of demographic and attitudinal characteristics. Three papers follow to evaluate the impact of dissonance on travel behavior: Schwanen and Mokhtarian (2003) compares non-commute trip frequencies of matched and mismatched urban and suburban residents; in the present paper, we compare the commute mode choice of consonant and dissonant workers; and Schwanen and Mokhtarian (in press) completes the picture by examining the role of dissonance in mode-specific distances traveled for all pur-

poses. Each study uses data from the same survey of commuters in three neighborhoods in the San Francisco Bay Area: the urban neighborhood of North San Francisco and the (different types of) suburban communities of Concord and Pleasant Hill. Because land use preferences and realities are taken into account as well as sociodemographics, mobility limitations, personality traits, and lifestyle factors, the empirical analyses presented in these studies offer deeper insights into the nature of the influence of land use characteristics on travel behavior.

The study background and hypotheses tested here are detailed in the following section. The paper then proceeds to a description of the data available for this study, as well as definitions of the variables used in the empirical analysis. Section 4 investigates the impact of neighborhood dissonance on commute mode choice through descriptive analysis, and Section 5 presents a multinomial logit analysis in which sociodemographic factors, mobility limitations, personality factors and lifestyle types are included as control variables. The paper concludes with a summary of the results and a discussion of the implications for land use and transport policy.

2. Study background

Mode choice for commute trips is probably the dimension of travel behavior that has been studied most thoroughly. Conventional wisdom holds that workers act as rational consumers and choose the mode providing the highest utility. This utility is typically a function of objective price or level of service factors—travel time and travel cost—and taste variables, usually represented by socioeconomic and demographic characteristics of households and sometimes supplemented by locational variables (Ben-Akiva and Lerman, 1985; Cervero, 2002). While most existing work has left at least one set of variables out of consideration (typically the locational and/or the price factors), basically all disaggregate studies have utilized sociodemographic taste variables, such as income, gender and household composition.

In the 1970s and early 1980s various researchers argued that the assumption of a direct link between objective level of service measures and reported behavior ignores the complexity of the traveler’s decision process (e.g., Recker and Golob, 1976; Koppelman and Lyon, 1981). Researchers should consider travelers’ subjective perceptions of and feelings toward modes, because these affect preferences toward modes. These together with situational constraints (e.g., car availability) determine mode choices. Thus, Koppelman and Lyon (1981) find that perceptions about convenience and general service

as well as feelings of affect and normative beliefs are positively correlated with a preference and hence choice for a given mode.

While attention to the attitude-travel behavior relationship faded during the 1980s, interest in the impact of attitudes on mode choice regained momentum with the shift in transportation policies from supply measures to travel demand management (TDM) and the underlying concerns about air quality and global warming (e.g., Fujii and Kitamura, 2003; Golob and Hensher, 1998; Hagman, 2003). Insights into the role of attitudinal factors are needed to formulate auto-use reducing policies that are more realistic in their objectives and perhaps more effective in terms of outcomes. Nonetheless, studies of the impact of attitudes as well as lifestyle and personality differences on commute mode choice have remained infrequent to date, not least because of the limited availability of appropriate data.

In addition to the rise of TDM, there is a second reason why it is pertinent to study the impact of travel attitudes, lifestyles and personality factors on mode choice, and this is closely related to the impact of locational factors on the level of auto commuting. The past 15 years have witnessed an enormous increase in studies of the impact of land use and infrastructure provision on travel behavior in general and mode choice in particular. Researchers have linked many dimensions of urban form—the configuration of land uses and infrastructure in an area—at a variety of spatial levels to commute mode choice. Conclusions about the relative importance of locational variables in commute mode choice are mixed, which is no doubt partly the result of the wide variation in research designs, theoretical frameworks, and data from different geographical settings utilized (Badoe and Miller, 2000; Crane, 2000). Nonetheless, a number of studies have shown that the share of driving a private vehicle to work decreases and the proportions of trips by public transit and bicycling and walking increase, as the *intensity* of land uses is higher; the *mixing* of land uses is higher; the neighborhood is more *pedestrian-friendly*; and/or *transit service quality* is better (Cervero, 1996a,b, 2002; Cervero and Kockelman, 1997; Cervero and Radisch, 1996; Frank and Pivo, 1994).

At least three reservations can be made with regard to this purported effect of the physical structure of neighborhoods on commute mode choice. First, it is generally accepted that neighborhood structure variables exert a stronger influence on mode choices for non-work trips (Cervero and Radisch, 1996; Van and Senior, 2000). Nonetheless, neighborhood physical structure does appear to affect commute mode choice. Second, while such an impact has been found for the average neighborhood resident, it is unclear to what extent it holds for all segments of the neighborhood population. The impact of urban form may differ across men and women, house-

hold types and socioeconomic groups (Badoe and Miller, 2000).

Third, as briefly discussed in the introduction, residential location choice may not be independent of commute mode choice. This implies that it is not a priori clear that residential location choice is exogenous to the relationship between land use configuration and commute mode choice. Households with a predisposition toward a certain type of travel may choose to locate in a neighborhood enabling the pursuit of the preferred type of travel. This phenomenon is referred to as *residential self-selection* in the literature on travel behavior and urban form (Boarnet and Crane, 2001; Cervero and Duncan, 2002; Handy, 1996; Sermons and Seredich, 2001; Van Wee et al., 2003).

The treatment of the impact of residential self-selection on travel behavior in empirical work is to some extent elusive. Empirical studies typically apply a residential location choice (sub)model to predict a household's (preferred) location, which is then used in a travel choice (sub)model. Usually sociodemographic factors are used to predict residential location together with characteristics of the choice alternatives (residential zones), in particular population composition, housing stock characteristics, and job accessibility (Boarnet and Crane, 2001; Cervero and Duncan, 2002; Sermons and Seredich, 2001). While such variables may capture part of households' preferences regarding travel, we are not aware of any study of joint choices of residential location and commute mode that has explicitly incorporated attitudes toward travel and land use as explanatory variables. In light of the previously mentioned studies which have shown attitudes to influence mode choice, we consider this situation unfortunate and therefore analyze the joint impact of locational factors and attitudinal variables on commute mode choice. Special attention is given to the impact of individuals' preference toward living in a high-density environment vis-a-vis that of physical neighborhood structure.

If the impact of preferences regarding the environment outweighs that of physical structure, this would suggest that residential self-selection is a relevant factor to be reckoned with when studying the link between urban form and travel behavior. If, on the other hand, statistically significant differences exist between residential neighborhood types after account is taken of differences in residential neighborhood type preferences as well as personality and lifestyle factors and attitudes toward traveling in general, we may conclude that physical neighborhood structure has an autonomous effect on commute mode choice.

The basic hypothesis underlying this research is that both sets of factors—physical neighborhood structure and preferences regarding physical neighborhood attributes—are at work simultaneously. Distinguishing (1) commuters currently residing in urban and suburban

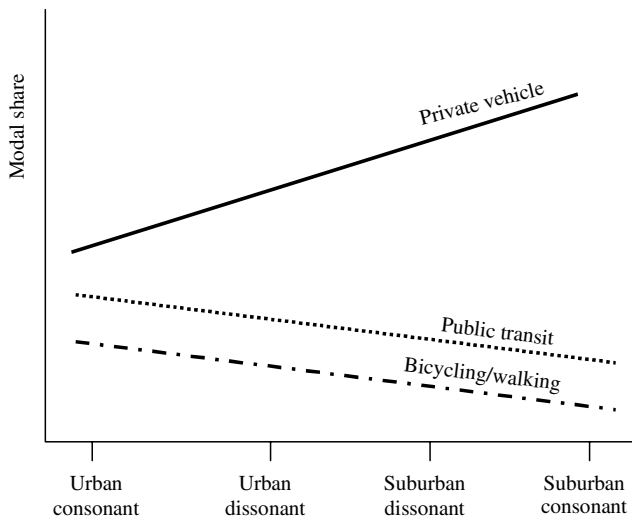


Fig. 1. Hypothesized continuum of actual and preferred residential neighborhood type and commute mode choice.

neighborhoods, and (2) commuters with urban and suburban land use preferences, we can compare the mode choice behavior of four population segments: urban residents with urban preferences (true urbanites); urban dwellers with suburban preferences (mismatched or dissonant urban dwellers); suburban residents with urban preferences (mismatched or dissonant suburban dwellers); and suburban dwellers with suburban preferences (true suburbanites). Residents in each of these segments are hypothesized to fall on a continuous scale in terms of their average probability of commuting by private vehicle or any alternative mode of transportation (Fig. 1).

Of course, the discrete situations in Fig. 1 are a simplification of a more complex reality. Our empirical analysis takes account of this complexity in two ways. First, the travel behavior of residents of three neighborhoods is studied: the urban neighborhood of North San Francisco and the different suburban neighborhoods of Concord and Pleasant Hill. Second, we have used a range of residential neighborhood type dissonance indicators, which are continuous or discrete in nature and are capable of accounting for the level of neighborhood attachment. Further, our behavior, attitude, and mismatch indicators are disaggregate, accounting for the reality that there is substantial variation, even among individuals in the same neighborhood, on travel and land use attitudes that are important to commute mode choice.

3. Data, definitions, and methods

3.1. Data

The data used for this study comprise responses to a 14-page questionnaire that collected information on a variety of travel and related issues. The survey was

mailed in May 1998 to 8000 randomly selected households of three neighborhoods in the San Francisco Bay Area. Half were mailed to the urban neighborhood of North San Francisco (Fig. 2); the other half were split evenly between the contiguous suburbs of Concord and Pleasant Hill (Fig. 3). A randomly selected adult member of the household was asked to complete the survey. About 2000 surveys were returned, yielding a 25% response rate. The subset of 1358 respondents identified as workers commuting at least once a month is used for the current analysis.

The three communities selected for the survey differ in terms of spatial layout and structure (Table 1). North San Francisco (Fig. 2) is a traditional neighborhood characterized by high densities or intensity of land use, a high level of mixing of residential and business locations, rectangular street patterns, good pedestrian facilities, and good access to the public bus system. The neighborhood is, however, not directly connected to the Bay Area Rapid Transit (BART) urban rail system. Homes and lots are relatively small and there is little parking space. Concord (Fig. 3) is more or less the reverse of this: building densities and the extent of land use mixing are lower, the street pattern is radiating rather than grid-like, access to BART is good but bus services are poor, houses and yards tend to be large and parking space is ample. Although Pleasant Hill is a suburban community characterized by cul-de-sac street patterns, and similar to Concord in its lack of pedestrian-friendliness and level of transit service, it differs in several respects from Concord. Building densities are considerably higher, for instance, but the connectivity of street networks is low. Further, distances to the nearest grocery store and park are relatively large, implying low levels of land use mixing (Bagley et al., 2002).

In terms of travel patterns, the survey asked respondents among other things about their objective mobility—distance and frequency of travel by mode and trip purpose, as well as the average travel time for the commute trip. No formal questions were asked about commute mode choice, to reduce the burden on the participants. However, applying a set of rules to the information about commute trip frequency, commute time, and travel distance by purpose and mode, we were able to identify for all respondents a main commute mode falling into one of five categories: driver/passenger in a private vehicle; bus/ferry; train/BART/light rail; walking/jogging/bicycling; and ‘other’ modes (including airplane). By comparing reported weekly miles traveled for commuting, one of five modes (personal vehicle/motorcycle, bus/ferry, train/BART/light rail, walking/jogging/bicycling, and other) was assigned to each individual as a primary commute mode. The assignment was made with 100% confidence for 13.5% (single-mode users) of the sample of 1358 commuting workers, with a high

North San Francisco

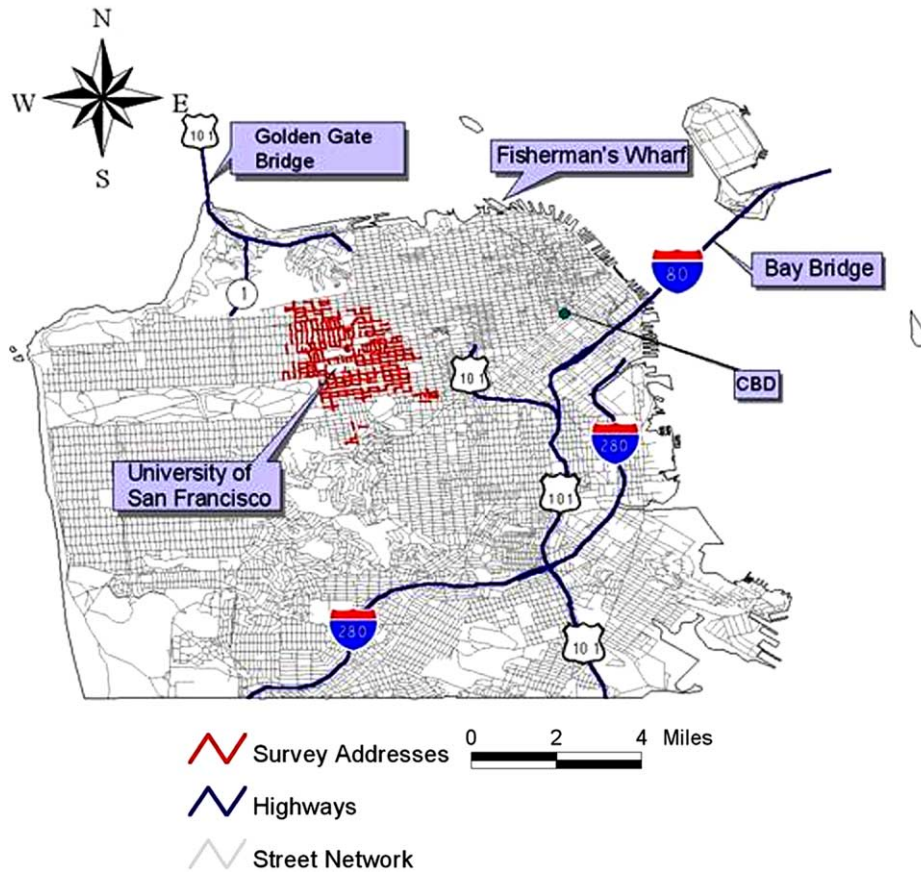


Fig. 2. North San Francisco study area.

degree of confidence for an additional 55.6% (those whose miles of travel by a single mode exceeded half their commute miles traveled, with travel by all other modes summing to less than half the commute miles), and with moderate confidence for the remaining 30.9% (by identifying the mode used for the greatest proportion of total weekly driving alone from carpooling, so the personal vehicle category includes both cases. For the 1358 commuting workers analyzed in this study, the shares of the primary commute modes are 79.4%, 9.7%, 8.2%, 2.4%, and 0.1%, respectively. Because of its very small share, the category of 'other' modes was excluded from the analysis.

The survey is unique in the sense that extensive information on a wide range of factors is available for the respondents, including personality traits, lifestyle orientation, travel and land use related attitudes, mobility constraints and sociodemographics (see Mokhtarian et al., 2001; Redmond, 2000 for detailed information on specific variables). Regarding personality, respondents were asked to indicate how well each of 17 words/phrases applied to them on a five-point scale from

“hardly at all” to “almost completely”. Through the application of factor analysis, these attributes were reduced to four underlying dimensions: the adventure seeker, organizer, loner, and the calm personality. The same procedure was followed for lifestyle. Eighteen Likert-type scale statements relating to work, family, money, status and the value of time were factor-analyzed, yielding four lifestyle dimensions: status seeker, workaholic, family/community-oriented and frustration factors. Factor analysis was also applied to 32 attitudinal statements related to travel, land use and the environment. Respondents were asked to respond on five-point Likert-type scales ranging from “strongly agree” to “strongly disagree”. Six relatively uncorrelated underlying dimensions could be identified, using principal-axis factoring with oblique rotation: travel dislike, pro-environmental policy, commute benefit, travel freedom, pro-high density, and travel stress factors. For the current study, the pro-high density dimension is particularly important (Section 3.2). This attitudinal dimension is characterized by the following statements (pattern matrix loadings in parenthesis):

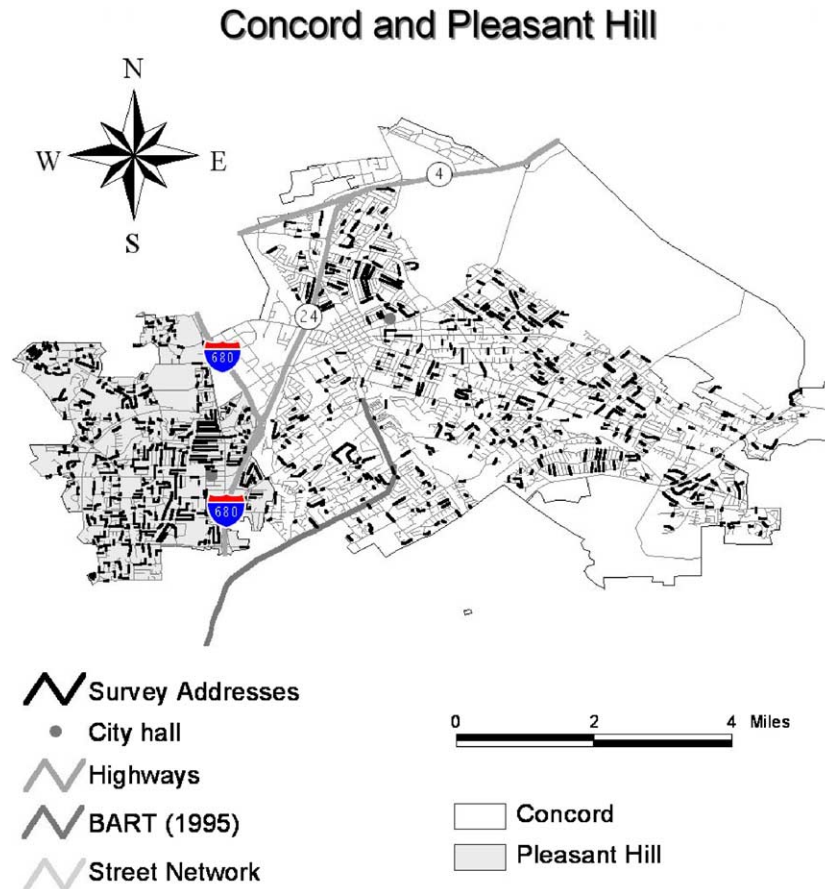


Fig. 3. Concord and Pleasant Hill study areas.

Table 1
Summary of spatial structure indicators for the communities surveyed

	North San Francisco	Pleasant Hill	Concord
Density	High	Intermediate	Low
Business locations	Throughout the neighborhood	Central near BART and Freeway	Western end of the neighborhood
Distance to San Francisco Central Business District	5 km	41 km	46 km
Street pattern	Grid	Fragmented	Radiating
Topography	Hills	Flat	Flat
Freeway access	I-80 1.5 km east	I-680 transects the community	I-680 on the western side; Hwy 24 transects the community
BART access	None	Southeast of neighborhood	West side of the neighborhood
Bus lines	21 bus routes	3 bus routes	3 bus routes
Sidewalks	Wide	Discontinuous	Discontinuous, missing
Walking	Common	Hazardous	Hazardous

Source: After Kitamura et al. (1997).

- Living in a multiple family unit would not give me enough privacy (−0.617).
- I like living in a neighborhood where there is a lot going on (0.486).
- Having shops and services within walking distance from my home is important to me (0.401).
- I like to have a large yard at my home (−0.323).

The respondent’s score on this pro-high density factor is assumed to reflect her preference structure regarding physical characteristics of the residential neighborhood. A high score thus suggests a strong preference for high density living.

Mobility constraints are defined as physical or psychological limits on travel. They have been measured

by questions about the existence of physical or psychological conditions that limit traveling by certain modes at certain times of day, with ordinal response categories “no limitations”, “limits how often/long”, and “absolutely prevents” (coded as 1, 2, and 3, respectively). Further, the questionnaire included an extensive list of questions on the respondents’ sociodemographic situation. On the basis of this information a household typology was created:

- Single workers: one adult, no children;
- Two-worker couples: two adults, each of whom is employed;
- One-worker couples: two adults, one of whom is employed;
- Multiple-worker families: households consisting of two or more working adults and one or more children aged 18 or less;
- One-worker families: households consisting of one working and one non-working adult and one or more children aged 18 or less;
- Multiple working adults: households consisting of three or more adults at least two of whom are employed, no children aged 18 or less are present; and
- ‘Other’ households, including among others single-parent families (one adult and one or more children).

Curry (2000) compared the distribution of key characteristics of our sample to those of the population (using Census data). The sample is roughly representative with respect to gender and commute time; however, higher educated and higher income individuals are overrepresented (which is quite usual for self-administered questionnaires). One-person households and households with two or more workers are underrepresented.

The variation among neighborhoods in sociodemographics, mobility limitations, personality and lifestyle and travel is considerable (Table 2). The largest differences can be noticed between urban North San Francisco and suburban Concord. Pleasant Hill usually takes an intermediate position; for most variables, however, Pleasant Hill residents resemble their counterparts in Concord more than North San Francisco inhabitants. Urban respondents tend to be younger and drawn from smaller households, often with two or more workers and less often with children. They are also less auto oriented than suburban respondents. Further, the neighborhood-wide averages for the (standardized) pro-high density factor scores clearly show that North San Francisco residents on average have much more positive attitudes toward urban living than do Pleasant Hill and especially Concord residents. Nevertheless, a sizeable portion of the respondents in each neighborhood has preferences regarding the physical aspects of the residential neigh-

borhood that differ from the characteristics of their current neighborhood type. The measurement of this neighborhood type dissonance is the topic of the following subsection.

3.2. Residential neighborhood type dissonance

Schwanen and Mokhtarian (2004) defined residential neighborhood type dissonance as an incongruence in terms of land use patterns between the neighborhood type where the individual currently resides and her preference structure toward such characteristics of the residential environment. They derive five indicators of residential neighborhood dissonance which are all based on the same principle: the respondents’ score on the standardized pro-high density factor (as a preference indicator) is contrasted with their actual neighborhood type.

The five measures can be summarized as follows (Table 3, more details in Schwanen and Mokhtarian, 2004). MM1 is a binary indicator with a value of one indicating that a respondent is mismatched. Roughly speaking, an urban resident is classified as dissonant if she has a negative value on the pro-high density factor, and a suburban resident is dissonant when she has a positive score. The appeal of MM1 is that it produces a straightforward estimate of the level of mismatch in a neighborhood; however, it does not reflect differences in the degree of dissonance. Therefore MM2 is defined for an urban resident as the maximum score on the pro-high density factor, minus the respondent’s real score, and similarly (in reverse) for a suburban resident. Actually, we did not use the maximum (minimum for suburban) score, but the 95th (5th) percentile score to make this indicator less sensitive to outliers. Scores more extreme than the 95th (5th) percentile were set equal to the cutoff point. Because of the associations between neighborhood attachment and neighborhood type dissonance, MM3 and MM4 are defined as interactions of MM1 and MM2 with an ordinal indicator of the level of attachment (1 = attached; 2 = somewhat attached; 3 = not attached). Lastly, MM5 is intended to be a very conservative dissonance indicator, preventing potential misclassification of residents as mismatched as much as possible. Urban (suburban) residents are considered dissonant only if their pro-high density factor score is extremely low (high) compared with the neighborhood average, i.e. a score that is lower (higher) than the neighborhood average minus (plus) one standard deviation.

Consistent with Feldman (1990), Schwanen and Mokhtarian (2004) find that in total about a quarter of the respondents is mismatched, as reflected by the binary indicator MM1. Analysis of the presence (MM1) and level (MM2) of dissonance by neighborhood indicates that Pleasant Hill residents are most and Concord residents least mismatched (Table 3). For MM3 and MM4 a similar picture emerges, although

Table 2
Descriptive statistics by residential neighborhood

	North San Francisco			Pleasant Hill			Concord					
	Mean	SD	N cases	Mean	SD	N cases	Mean	SD	N cases			
<i>Sociodemographics</i>												
Ratio of vehicles to valid driver's licenses	0.82	0.47	642	1.11	0.41	357	1.14	0.51	307			
Household income (\$1000) ^a	69.9	30.7	656	75.3	37.0	354	69.6	27.1	311			
Respondent's age (years) ^a	40.6	11.7	670	46.4	11.6	369	46.4	10.6	317			
<i>Mobility limitations</i>												
Driving during the day	1.03	0.18	669	1.01	0.14	369	1.01	0.08	317			
Driving at night	1.06	0.28	669	1.04	0.20	369	1.04	0.19	317			
Driving on the freeway	1.05	0.25	669	1.03	0.20	369	1.01	0.14	317			
Using public transit	1.04	0.22	669	1.04	0.22	369	1.03	0.22	317			
Riding a bicycle	1.09	0.37	669	1.11	0.36	369	1.09	0.35	317			
Walking	1.03	0.19	669	1.06	0.27	369	1.03	0.19	317			
<i>Personality traits</i>												
Adventure seeker factor	0.18	0.86	671	-0.03	0.96	369	-0.11	0.96	318			
Organizer factor	-0.05	0.82	671	0.09	0.78	369	0.08	0.80	318			
Loner factor	0.19	0.89	671	-0.05	0.90	369	-0.05	0.93	318			
Calm factor	-0.08	0.81	671	-0.04	0.86	369	0.04	0.76	318			
<i>Lifestyles</i>												
Frustration factor	0.01	0.84	671	0.07	0.80	369	0.07	0.85	318			
Family/community orientation factor	0.05	0.72	671	0.04	0.73	369	0.05	0.72	318			
Status seeker factor	0.10	0.79	671	0.01	0.79	369	0.10	0.79	318			
Workaholic factor	0.04	0.80	671	0.00	0.72	369	0.04	0.80	318			
<i>Travel and land use-related attitudes</i>												
Travel freedom factor	-0.04	0.78	671	0.07	0.68	369	0.03	0.71	318			
Pro-environmental policy factor	0.34	0.84	671	-0.31	0.77	369	-0.34	0.72	318			
Pro-high density factor	0.47	0.66	671	-0.38	0.69	369	-0.54	0.64	318			
<hr/>												
	N cases		Percentage		N cases		Percentage		N cases		Percentage	
<i>Sociodemographics</i>												
<i>Household type</i>												
Single worker	212	31.6	73	19.8	39	12.3						
Two worker couple	212	31.6	115	31.2	71	22.3						
One worker couple	29	94.3	26	7.0	34	10.7						
Multiple worker family	89	13.3	89	24.1	114	35.8						
One worker family	22	93.3	29	7.9	19	6.0						
Multiple working adults	61	9.1	19	5.1	16	5.0						
'Other' household	28	4.8	14	3.8	18	5.7						
<i>Gender</i>												
Female	329	49.4	199	53.9	163	51.6						
<i>Occupation type</i>												
Service/repair	29	4.3	24	6.5	20	6.3						
Sales	55	8.2	35	9.5	31	9.7						
Production/construction/crafts	18	2.7	9	2.4	23	7.2						
Manager/administrator	148	21.6	90	24.4	60	18.9						
Clerical/administrative support	66	9.9	50	13.6	33	10.4						
Professional/technical	348	52.2	157	42.5	143	45.0						
'Other' occupation	7	1.0	4	0.8	8	2.5						

^a Mean category midpoint is used as estimate of the true value.

North San Francisco and Concord have the same score for the latter. Note that, by the nature of its definition, the presence of mismatch reflected by MM5 is about 16% in all neighborhoods.

4. Descriptive analysis

Not surprisingly, the driver/passenger in a personal vehicle category dominates the mode split: 76.9% of

Table 3
Residential neighborhood type dissonance indicators and scores by neighborhood

Definition ^a	North San Francisco			Pleasant Hill			Concord					
	0 ^b (%)	1 (%)	2 (%)	3 (%)	Mean	SD	0 (%)	1 (%)	2 (%)	3 (%)	Mean	SD
MM1 _i 1 if ProHiDens _i < 0 if NSF _i = 1 1 if ProHiDens _i > 0 if PH _i = 1 or CON _i = 1 0 otherwise	76.1	23.9			72.9	27.1	81.1	18.9				
MM2 _i ProHiDens _{max} - min(ProHiDens _{max} , ProHiDens _i) if NSF _i = 1 max(ProHiDens _i , ProHiDens _{min}) - ProHiDens _{min} if PH _i = 1 or CON _i = 1					0.88	0.63					0.98	0.64
MM3 _i MM1 _i * ATTACH _i	76.6	12.9	8	2	72.8	12.6	81.1	8	8	2		
MM4 _i MM2 _i * ATTACH _i					1.36	1.24					1.56	1.27
MM5 _i 1 if ProHiDens _i < -0.192 if NSF _i = 1 1 if ProHiDens _i > 0.307 if PH _i = 1 1 if ProHiDens _i > 0.098 if CON _i = 1 0 otherwise	84.6	15.6			84.6	15.4	83.3	16.7			1.37	1.20

Source: After Schwanen and Mokhtarian (2004).

^a For respondent *i* the mismatch indicators MM1_i - MM5_i are defined as functions of: ProHiDens_i = the pro-high density factor; ATTACH_i = an ordinal indicator of the level of attachment to the current neighborhood [1 = attached; 2 = somewhat attached; 3 = not attached]; NSF_i/PH_i/CON_i = dummies indicating whether respondent *i* lives in North San Francisco, Pleasant Hill, or Concord.

^b Interpretation of discrete scores: 0 = consonant; 1 = dissonant; 2 more dissonant; 3 = most dissonant.

the respondents in the whole sample commute by this alternative. The second largest share is that for bus/ferry (9.7%), which is due to the large number of North San Francisco residents in the total sample. Segmented by neighborhood, we see that the personal vehicle class is even more dominant for suburban respondents (88.5%). The differences with North San Francisco are marked: although the private vehicle category is dominant here too (70.4%), a significant share of 19.4% use the bus/ferry to commute to their workplaces. The share of the slow modes (walking/jogging/bicycling) at 4.6% (versus 0.3% for the suburbs) is also larger, but still limited. In contrast, the share of the rail category is much lower than in the suburban communities—5.4% against 11.1%—reflecting the relatively poor access North San Francisco residents have to the Bay Area Rapid Transit (BART) system. Nonetheless, the results confirm the assertions in Section 2 that automobile use is lower in higher density, more mixed use and pedestrian-friendly neighborhoods with rectangular street patterns, in favor of public transit and slow modes of transportation.

Residential neighborhood type dissonance is significantly related to commute mode choice but only for North San Francisco residents (Table 4). Using the binary mismatch indicator MM1, we have found that dissonant urban respondents travel to work less frequently by any of the alternatives to the private vehicle. The difference is largest, however, for the bus/ferry category. For Pleasant Hill and Concord either separately or combined, no statistically significant differences (at the 5% or 10% level) between matched and mismatched residents can be detected. Table 4 shows that only among Concord residents does there exist a slight tendency for dissonant respondents to commute more frequently by rail. The other dissonance indicators produce similar results for the individual neighborhoods. For the sake of brevity, they are not presented here.

As the results for MM1 suggest (Table 4), the level of auto commuting for mismatched urban respondents falls in between that for well-matched urbanites and suburbanites, providing partial support for our hypothesis of a latent continuum ranging from consonant suburban to well-matched urban neighborhood inhabitants in terms of the propensity of commuting by private vehicle. To investigate this hypothesis further we have graphically reproduced the shares of the private vehicle alternative for different levels of neighborhood mismatch as reflected by the more fine-grained MM2 and MM3 indicators. Figs. 4 and 5 provide some additional support for the hypothesis: for both measures the share of the personal vehicle increases with the degree of mismatch among North San Francisco residents. As the score in the MM2 indicator increases up to 1.2 for suburban respondents, the

Table 4
Commute mode choice by residential neighborhood dissonance (MM1), and residential neighborhood

	North San Francisco				Pleasant Hill				Concord				Suburban pooled			
	Consonant		Dissonant		Consonant		Dissonant		Consonant		Dissonant		Consonant		Dissonant	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Personal vehicle	339	66.5	132	83.0	239	88.8	90	90.9	228	88.4	50	83.3	467	88.6	140	88.1
Bus/ferry	113	22.2	18	11.3					1	0.4	0	0	1	0.2	0	0
Train/BART/light rail	32	6.3	4	2.5	29	10.8	9	9.1	28	10.9	10	16.7	57	10.8	19	11.9
Walking/jogging/bicycling	26	5.1	5	3.1	1	0.4	0	0	1	0.4	0	0	2	0.4	0	0
Total	510	100	159	100	269	100	99	100	258	100	60	100	527	100	159	100
	$\chi^2 = 16.164; p = 0.001$				$\chi^2 = 0.603; p = 0.740$				$\chi^2 = 1.983; p = 0.576$				$\chi^2 = 1.051; p = 0.789$			

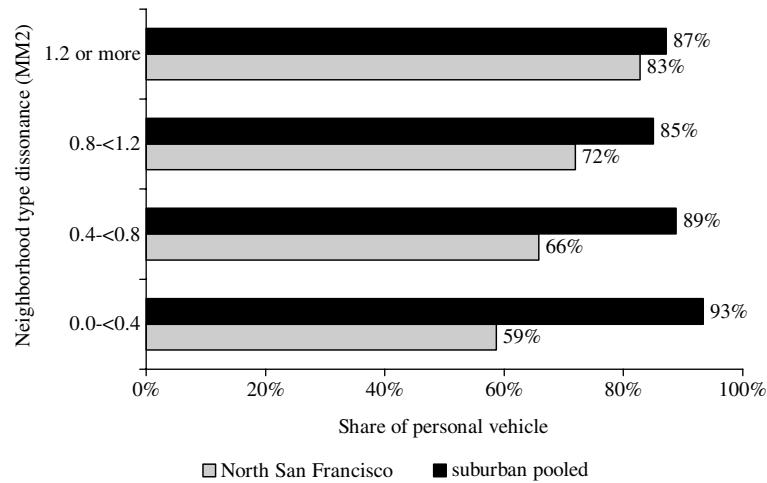


Fig. 4. Share of private vehicle for commuting, by neighborhood type and level of residential neighborhood type dissonance (MM2).

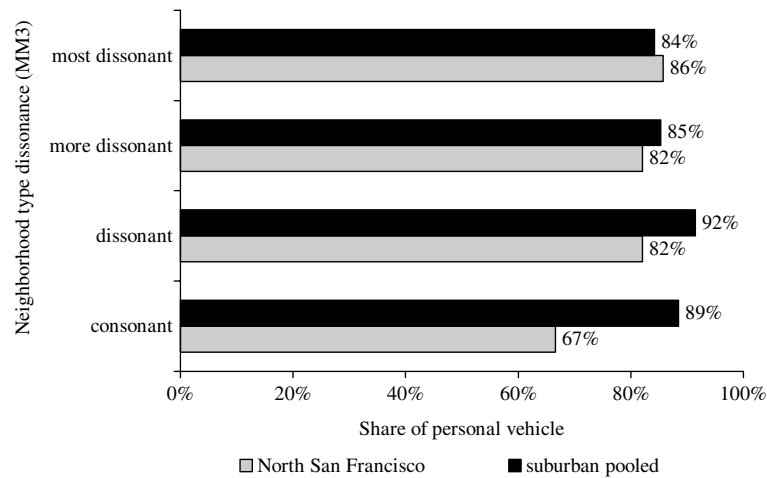


Fig. 5. Share of private vehicle for commuting, by neighborhood type and level of residential neighborhood type dissonance (MM3).

level of personal vehicle use drops. However, there seems to be some minimum threshold for the level of vehicle use at about 85%, because its share is 87% even for the most dissonant suburbanites. With respect to MM3, the propensity of commuting in a private vehicle is slightly lower among the more and most dissonant

suburban respondents than among consonant and least dissonant residents of Pleasant Hill or Concord (Fig. 5). The shares of the personal vehicle alternative are hence almost equal for the most dissonant residents in both urban and suburban neighborhoods. Nevertheless, the differences among the three

dissonance classes are small and not statistically significant.

5. Multinomial logit analysis

Although the descriptive analysis suggests that the level of neighborhood type dissonance affects commute mode choice, the question remains whether this holds true after other factors—sociodemographics, mobility limitations, personality and lifestyle types, and travel attitudes (Table 2)—are taken into account.

A convenient and common functional form for analyzing the influence of potential explanatory variables on a categorical dependent variable is the multinomial logit (MNL) model. The MNL model assumes that travelers have unobservable, latent preferences or utilities for different transport modes and that they choose the mode providing the highest utility (Ben-Akiva and Lerman, 1985). The utility associated with a transportation mode consists of two components—a deterministic part reflecting the influence of observed factors relating to sociodemographic, mobility limitations, personality, lifestyle and neighborhood factors, and a random part capturing all unobserved impacts. In the MNL model the random terms are assumed to be identically and independently Gumbel distributed. While this makes the model easy to estimate, it also leads to the independence from irrelevant alternatives (IIA) property, which limits the applicability of the MNL model. The IIA property implies that improvements in the attractiveness of one choice alternative results in proportionally identical decreases in the disaggregate choice probabilities of all other alternatives (Ben-Akiva and Lerman, 1985). In instances of correlations between the random terms in the utility functions of different alternatives, the IIA assumption does not hold and MNL results should not be used. Several ways of testing whether IIA holds have been developed. One of these is to compare MNL with an alternative model form that does not involve the IIA assumption (Fry and Harris, 1996), such as the nested logit (NL) model. In NL models alternatives that are suspected to be similar are placed together in one branch, whereas distinct alternatives are put in different branches. If the inclusive value (IV) coefficient for the branch is significantly less than one, the IIA property is not valid and the MNL results have to be rejected. If, however, the IV coefficient is not statistically different from one, this suggests that MNL outcomes are adequate.

For the current paper MNL and NL models have been developed in which indicators of sociodemographic situation, mobility limitations, personality, lifestyle, and travel-related attitudinal factors (Table 2) were allowed to be included as control variables in addition to a set of neighborhood dummy indicators and interactions of

residential neighborhood and neighborhood type dissonance indicators. Decisions regarding the final specifications were made on the basis of conceptual plausibility and statistical support using *t*-tests and χ^2 -statistics. Because no IV coefficients in any of the nested logit models were found to differ statistically significantly from one, we further concentrate on the MNL outcomes.

As Table 5 shows, two final models—one with and one without travel-related attitudinal factors—are presented because travel-related attitudes and neighborhood type dissonance are related to each other. Focusing attention on the neighborhood variables in the model without travel-related attitudes, we see results that are largely consistent with the descriptive analysis above. The probability of commuting as driver/passenger in a private vehicle (PV) and by train/BART/light rail is lower for North San Francisco than for suburban residents. In addition, MM2 is included for North San Francisco residents with a positive coefficient for the private vehicle mode. Thus, as the level of residential neighborhood dissonance increases for urban dwellers, the probability of commuting by private vehicle rises. Interestingly, the coefficients for these two variables differ considerably in magnitude: a score of 9.85 on MM2 is needed to compensate for the depressing effect that residing in North San Francisco has on commuting by private vehicle. The maximum score for MM2 observed in the sample is, however, 3.11. According to the model, suburban-minded urban residents will not exhibit the same propensity of commuting by private vehicle as true suburbanites.

While no statistically significant effects of neighborhood type dissonance on commute mode choice could be detected for suburban residents from the descriptive analysis, the model suggests that, after accounting for many other explanatory factors, the level of mismatch does affect their commute mode choice. The effects for Concord and Pleasant Hill residents are, however, only statistically significant at the 15% level. Remarkably, the coefficients for Pleasant Hill and Concord have opposite signs. The effect for Concord is as expected: as the level of residential neighborhood type mismatch rises, the probability of commuting by private vehicle falls, reinforcing earlier conclusions of a continuum ranging from well-matched suburbanites to consonant urbanites.

In contrast, for Pleasant Hill residents a higher level of mismatch is associated with a higher probability of commuting by private vehicle. The explanation for this unexpected result is not clear. It appears that this sign reflects a residual effect which shows up only when the impact of other factors has been controlled. This effect may result from the inadequate classification of Pleasant Hill respondents as mismatched (Schwanen and Mokhtarian, 2004). While we have used individual-specific measures of the pro-high density factor, we do not have

Table 5
Multinomial logit model for commute mode choice

	Model without travel attitudes		Model with travel attitudes	
	Coefficient	<i>t</i> -statistic	Coefficient	<i>t</i> -statistic
Alternative-specific constant (specific to bus)	−0.885	−0.510	−0.597	−0.337
Alternative-specific constant (specific to rail)	−0.682	−0.613	−0.195	−0.164
Alternative-specific constant (specific to slow)	−3.343	−2.430	−3.082	−2.216
<i>Sociodemographics</i>				
Respondent's age (in yr.) (specific to bus)	−0.033	−2.800	−0.031	−2.609
Single worker (specific to bus)	0.822	3.147	0.767	2.918
Female in two-worker couple (specific to PV)	−0.572	−2.692	−0.549	−2.559
Female in one-worker family (specific to slow)	2.346	2.753	2.425	2.849
Female in multiple working adults (specific to PV)	−0.986	−2.222	−0.940	−2.093
Ratio of vehicles to valid driver's licenses (specific to PV)	2.388	7.549	2.094	6.470
Ratio of vehicles to valid driver's licenses (specific to rail)	1.183	2.424	1.014	2.442
Household income (\$1000) (specific to slow)	−0.020	−2.656	−0.019	−2.524
Professional/technical occupation (specific to bus)	−0.760	−3.085	−0.842	−3.399
<i>Mobility limitations</i>				
Driving a vehicle during the day (specific to PV)	−1.580	−2.059	−1.344	−1.744
Driving a vehicle during the day (specific to bus)	1.344	1.714	1.346	1.719
Using public transit (specific to PV)	2.036	2.146	2.136	2.180
Walking (specific to bus)	−2.778	−2.080	−2.697	−1.984
Riding a bicycle (specific to bus)	0.626	1.906	0.569	1.724
<i>Personality types</i>				
Adventure seeker factor (specific to PV)	0.283	2.876	0.199	1.917
<i>Lifestyle types</i>				
Frustration factor (specific to rail)	0.280	2.097	0.264	1.968
Status seeker factor (specific to rail)	−0.598	−3.797	−0.528	−3.336
<i>Travel attitudes</i>				
Travel freedom factor (specific to PV)			0.342	2.668
Pro-environmental policy factor (specific to PV)			−0.465	−3.949
<i>Neighborhood indicators</i>				
North San Francisco resident (specific to PV)	−4.119	−5.450	−3.361	−4.584
North San Francisco resident (specific to rail)	−4.476	−5.885	−4.520	−5.931
MM2 for North San Francisco resident (specific to PV)	0.418	2.191		
MM3 for Pleasant Hill resident (specific to PV)	0.408	1.503	0.600	2.198
MM4 for Concord resident (specific to PV)	−0.171	−1.583		
<i>Model statistics</i>				
Log likelihood at constants	−806.2		−806.2	
Log likelihood at convergence	−593.2		−585.9	
χ^2	425.9		440.6	
Number of observations	1165		1165	
ρ^2 (market share model as base)	0.264		0.273	
Adjusted ρ^2 (market share model as base)	0.259		0.268	

“PV” stands for personal vehicle; “rail” for train/BART/light rail; “bus” for bus/ferry; and “slow” for bicycling/walking/jogging.

individual-specific measures of neighborhood type available in the data. The same binary value (urban or suburban) is given to every respondent in a given neighborhood. Bagley et al. (2002) showed, however, extensive variation in perceived neighborhood characteristics exhibited by residents of the same neighborhood. Hence, we may be classifying as mismatched some suburban residents who have in fact more or less realized their pro-high density preferences. This is particularly likely to happen in Pleasant Hill which has the largest heterogeneity of residence types of the three neighborhoods investigated. The estimation results of

a model specification in which the interaction term of residing in Pleasant Hill and MM3 is replaced by an interaction term containing MM5 (which was specifically designed to minimize misclassification of residents as mismatched, see Section 3.2) support the above argument: the estimated coefficient is not significant at the 80% confidence level. We decided to include the model with MM3 in the paper, because it is statistically superior to models with MM5 or without any dissonance term for Pleasant Hill residents, and because it illustrates the complexity of the concepts and relationships under study here.

The results for the model with travel attitudes provide further support for the above explanation for the positive coefficient of MM3 for Pleasant Hill respondents. The coefficient has become statistically significant at the 5% level after the travel freedom and pro-environmental factors are included, whereas those for the dissonance indicators for Concord and North San Francisco residents became insignificant and are hence omitted from the model specification. In this case too, a model with MM5, which is only significant at the 10% level, and a model without a dissonance term for Pleasant Hill residents are statistically inferior to the model shown here.

The positive effects of the travel freedom factor and pro-environmental factors on the probability of commuting by private vehicle are in line with expectations. Workers with a positive score on the pro-environmental factor hold a (rather) positive view of policies seeking to moderate the adverse environmental consequences of vehicle travel through pricing of auto use, the introduction of clean-fuel vehicles, and the promotion of public transit (Mokhtarian et al., 2001; Redmond, 2000). It is hence not surprising that these people limit their auto travel. As the name implies, a positive score on the travel freedom factor indicates that travelers perceive relatively few financial, comfort-related and/or spatio-temporal constraints on traveling. The availability of a flexible means of transport clearly contributes to such opinions. This factor may thus partly function as an indicator of vehicle availability.

Complex interactions exist between travel freedom and pro-environmental attitudes on one hand and residential neighborhood type mismatch on the other, for North San Francisco and Concord respondents (Table 5). Mismatched urban residents not only prefer a lower density residential neighborhood, they also tend to disapprove of policies attempting to limit auto travel and value the flexibility a private vehicle offers. Their suburban land use preferences go hand in hand with a strong auto orientation. Once this orientation is accounted for, the positive effect of neighborhood type dissonance on the probability of using a personal vehicle becomes insignificant. The opposite mechanism seems to be at work for mismatched Concord residents: a (somewhat) more positive score on the pro-high density factor complements a lower auto orientation as reflected in a lower score on the travel freedom and higher score on the pro-environmental policy factors. These results suggest that, at least for the current sample, commuters' beliefs about personal vehicle use—especially those regarding the advantages it offers at the individual level (reflected by the travel freedom factor) as well as the negative consequences for society at large (reflected by the pro-environmental factor)—are relevant to the issue of residential self-selection. The pro-environmental policy and travel freedom factors also turned up in a discrete

choice analysis of residential location choice, showing that commuters with a higher score on the former and lower on the latter are more likely to reside in the urban neighborhood of North San Francisco (Schwanen and Mokhtarian, submitted for publication). Thus, commuters' opinions about the individual benefits accruing from auto use and the costs involved for society are relevant to the interdependent choices of residential location and commute mode.

A considerable number of additional variables are included in both final model specifications. The signs of the estimated coefficients are as expected. Concerning sociodemographic variables, the ratio of vehicles to valid driver's licenses is positively related to the probability of commuting by private vehicle and by train/BART/light rail. The latter coefficient reflects that most rail commuters reside in Pleasant Hill and Concord, where the level of auto ownership is larger than in urban North San Francisco. In addition, household income is negatively related to the likelihood of commuting by walking/jogging/riding a bicycle, while workers with a professional/technical occupation have a lower chance of commuting by bus/ferry.

Demographic variables are also significantly related to commute mode choice. As workers are older, they have a lower chance of commuting by bus/ferry. In contrast, single workers have a higher probability of using bus/ferry, which seems to reflect that singles are more likely to reside in North San Francisco (Schwanen and Mokhtarian, submitted for publication) and less frequently own a private automobile. Three additional household structure variables are included, but their impact only pertains to women in the household. Females in two-worker couples and in households consisting of three or more adults at least two of whom are employed are less likely to commute by auto. As earlier work indicated (Schwanen and Mokhtarian, submitted for publication), these household types are over-represented in urban North San Francisco. There, bus/ferry and bicycling/walking can function as viable alternatives to a private vehicle. The model also indicates that females in one-worker families have a higher chance of commuting by slow modes. Such modes of transport may be more acceptable to women than to men, because their commutes tend to be shorter than men's are (Turner and Niemeier, 1997). The estimation results may also reflect women's lower bargaining power in household negotiations of auto use (Law, 1999; Pickup, 1984).

Mobility constraints are also related to commute mode choice. Workers indicating that they have physical or psychological limitations preventing them from driving a private vehicle are less likely to commute by private vehicle, instead shifting to the bus/ferry mode. Likewise, persons who have difficulties with traveling by public transit seem to shift to the auto alternative. Workers suffering from limitations on walking are less

likely to commute by bus/ferry for which walking is an important access and egress mode. Most likely these persons will also experience serious problems when boarding and getting off buses. In contrast, workers facing difficulties with riding a bicycle have a higher chance of commuting on a bus/ferry, suggesting that limitations on riding a bicycle are less restrictive than those preventing people from walking.

Three personality and lifestyle factors show up in the final models. An adventure seeking personality is associated with a larger chance of using the private vehicle alternative, which may be associated with the fact that a private vehicle is a more flexible mode of transportation facilitating the engagement in unplanned, non-routine activities than are public transit modes (Hensher and Reyes, 2000). Workers with a high score on the frustration factor are more likely to commute by train/BART/light rail. These persons agree with statements about a lack of control over their life and often feel dissatisfied with their lives (Mokhtarian et al., 2001; Redmond, 2000). Although part of this lack of control may stem from the fact they cannot drive a private vehicle to work, it is also possible that the frustration factor is serving as a marker for other constraints that affect mode choice. Lastly, status seekers have a higher probability of commuting by private vehicle. The most important statement defining this factor is whether the auto functions as a status symbol (Mokhtarian et al., 2001; Redmond, 2000). In their structural equations model of travel behavior of residents of 6 Australian cities, Golob and Hensher (1998) also find that people for whom the car is a status symbol are more likely to drive alone to work.

The last set of explanatory variables is the alternative-specific constants. Their estimated coefficients show that the average effect of the unobserved factors is to favor the private vehicle alternative over the other three alternatives. However, only for the slow modes of transport is this impact statistically significant. In terms of model fit, both models perform reasonably well. Taking the market share model as the base, adjusted ρ^2 s are 0.259 and 0.268 for the models with and without travel-related attitudes, respectively. The null hypothesis of equivalence between the market share and the full models is clearly rejected in both instances.

6. Discussion and conclusion

This paper has sought to enhance our understanding of the complicated relationships among residential location, commute behavior, and attitudes toward land use and travel. We have investigated to what extent commute mode choice differs not only by residential neighborhood but also by the presence and level of mismatch between a commuter's current and preferred

type of neighborhood. Hence, the work reported here provides insights into the question of the relative importance of individuals' preferences toward, versus the conditioning effects of, the spatial environment in shaping their travel patterns.

The analysis has largely confirmed our hypothesized continuum ranging from well-matched urbanites through dissonant urban and suburban residents to consonant suburbanites, where the first have the highest probability of commuting by public transit, by bicycle or on foot and the last group are most inclined to commute by auto. Thus, dissonant residents of urban North San Francisco are far more likely to commute by private vehicle than consonant urbanites but not quite as likely as suburbanites. Among suburban residents the impact of dissonance is much weaker. For Concord the relationship only shows up after account is taken of differences in sociodemographics, mobility limitations, personality types and lifestyle differences. The impact of dissonance disappears among both North San Francisco and Concord residents when travel-related attitudes are included in the model specification, showing that residential neighborhood type mismatch is closely associated with perceptions of travel freedom and a predisposition toward pro-environmental policies. Pleasant Hill residents take a specific position in terms of the influence of neighborhood type on commute mode choice. We have argued that the impact of the level of dissonance in this community showing up in the final models is most likely a residual effect resulting from the potential misclassification of many Pleasant Hill residents as mismatched.

Based on the above results, we believe that, at least for commute mode choice, in the suburban neighborhoods the conditioning influence of the environment prevails over travelers' preferences regarding their residential environment. In the urban neighborhood, on the other hand, the relative contributions of preferences toward and constraints imposed by the physical structure to the explanation of travel patterns are more balanced. The difference between these two outcomes may well lie in the degree of choice available to the residents of each type of neighborhood. Although mismatched suburban residents may be more inclined to use transit than their matched neighbors, many may feel they have no choice (given the mismatch between the transit level of service available to them and, e.g., the location of their workplace and their lifestyle constraints) but to commute by personal vehicle. In North San Francisco, by contrast, mismatched urban residents may be more inclined than their matched neighbors to commute by personal vehicle, *and many of them do*. The relatively good transit service increases their options, and many of them take advantage of that, but the personal vehicle is still a realistic option for those with the proclivity to use it.

Regarding the interaction of residential location choice and commute behavior, our results suggest that residential self-selection processes do play a significant role in explaining travel patterns. Nevertheless, neighborhood structure appears to have an autonomous influence, based on two results. First, after predisposition toward traveling, and personality and lifestyle differences have been taken into account, neighborhood dummy indicators show up in the final models. Second, the models indicate that differences between consonant and dissonant residents within North San Francisco do not appear to be as large as differences between this urban and the two suburban neighborhoods. Further, the results suggest that studies into residential self-selection may benefit from explicitly addressing travelers' valuations of the benefits and costs automobile use entails for individuals as well as the wider society. However, more refined analyses than ours of the interdependence of these attitudes with residential and travel choices are warranted.

Several additional avenues for further research can be identified. First, it is pertinent to scrutinize the impact of neighborhood type dissonance on other dimensions of travel/activity patterns. In particular, the influence on travel distance may be analyzed, because this is another dimension of travel behavior that is sensitive to characteristics of the built environment (Badoe and Miller, 2000; Hanson and Schwab, 1987). Second, because the data utilized here were not collected with the current study purpose in mind, only a few neighborhood types could be studied. For future investigations of neighborhood type dissonance, we recommend the collection of travel data from residents of a much wider range of suburban neighborhoods differing in terms of land use mixing, connectivity of street patterns, and availability of public transit services. Third, more detailed mismatch indicators based on individual-specific assessments of the residential neighborhood characteristics (Bagley et al., 2002) may be related to travel behavior. This would most likely reduce the sometimes counterintuitive results for Pleasant Hill in the multivariate analyses outlined earlier. It may also be fruitful to apply dissonance indicators accounting for travelers' preferences regarding the social and dwelling components of the neighborhood concept (see Section 3.2). Fourth, it is worthwhile to pay more attention to the impact of dynamics in travelers' life course. Travelers' family, residential and employment histories were hypothesized to affect the level of neighborhood type dissonance in Schwanen and Mokhtarian (2004), but they may also affect the relation between mismatch and commuting. The current data contained a variable reflecting the length of stay in the current neighborhood but this was not related to commute mode choice (and therefore not discussed here so far). However, other personal history variables may well be relevant to the relations under study. Finally, it

would be interesting to conduct similar investigations in other geographical settings, in particular those with more stringent controls on land use. One would expect mismatch to be more prevalent there (although it is likely that residential preferences are modified in such situations through cognitive dissonance reduction mechanisms to minimize residential dissatisfaction), and hence to have a more profound influence on travel patterns.

What lessons for policymaking can be drawn from this study? On the positive side, we have found that urban residents with suburban land use preferences will exhibit some travel patterns that are more beneficial to the environment than those of true suburbanites (e.g., with a 83% personal vehicle commute mode share for the most mismatched urban dwellers in Fig. 4, compared to 93% for the consonant suburban dwellers). In addition, our analysis suggests that, at least in the Bay Area, urbanite-at-heart suburban residents may under certain conditions modify their travel behavior. For one thing, the 87% personal vehicle commute mode share of the most mismatched suburban dwellers is still lower than that of their true suburbanite neighbors (93%). Further, it seems likely that the personal vehicle share among the mismatched suburbanites could be lowered even more if viable alternatives to the automobile (in terms of travel time, convenience, and comfort) were made available to them.

Also, the finding that a quarter of the sample in each type of neighborhood was mismatched suggests that it could be more worthwhile to try and find ways to improve the match—particularly of urbanites-at-heart in the suburbs, since better matching in the other direction may not reduce personal vehicle travel. That is, rather than trying to motivate suburbanites-at-heart to move to urban areas against their true preferences, simply make it easier for those who want to live in such areas anyway to do so (Levine, 1999). Increasing the supply of such neighborhoods is clearly one important strategy, which would help reduce the price premium they currently often command in the market. Subsidizing that higher price, on the other hand, may have the undesired effect of attracting suburbanites-at-heart “for the wrong reasons”, whose travel patterns then may not be what policymakers had in mind. In our sample, the fact that the 83% personal vehicle commute mode share of the most mismatched urban residents is considerably higher than the 59% share of their true urbanite neighbors calls into question the acclaimed transportation benefits of neo-traditional neighborhoods. In the longer run, this may have adverse consequences for residents of such developments with a true preference for higher-density living. If public transit patronage remains below expectations, service may be limited, which in turn may force true urbanites to shift (back) to the private automobile.

Ultimately, however, given the constraints and competing objectives faced by the typical households

considering a residential location, there may well be a natural limit on the extent to which they can be matched to their desired residential area type. Further research and experimentation are needed to illuminate the complex interplay of these relationships, and their implications for policy and planning.

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References

- Badoe, D.A., Miller, E.J., 2000. Transportation-land use interaction: empirical findings in North America, and their implications for modeling. *Transportation Research D* 5, 235–263.
- Bagley, M.N., Mokhtarian, P.L., Kitamura, R., 2002. A methodology for the disaggregate, multidimensional measurement of residential neighbourhood type. *Urban Studies* 39, 689–704.
- Ben-Akiva, M., Lerman, S.R., 1985. *Discrete Choice Analysis: Theory and Application to Travel Demand*. The MIT Press, Cambridge, MA and London, UK.
- Boarnet, M.G., Crane, R., 2001. *Travel by Design: The Influence of Urban Form on Travel*. Oxford University Press, Oxford, UK.
- Cervero, R., 1996a. Traditional neighborhoods and commuting in the San Francisco Bay Area. *Transportation* 23, 373–394.
- Cervero, R., 1996b. Mixed land uses and commuting: evidence from the American Housing Survey. *Transportation Research A* 30, 361–377.
- Cervero, R., 2002. Built environments and mode choice: toward a normative framework. *Transportation Research D* 7, 265–284.
- Cervero, R., Duncan, M., 2002. Residential Self Selection and Rail Commuting: A Nested Logit Analysis. University of California Transportation Center, Berkeley, CA.
- Cervero, R., Kockelman, K., 1997. Travel demand and the 3 Ds: density, diversity and design. *Transportation Research D* 2, 199–219.
- Cervero, R., Radisch, C., 1996. Travel choices in pedestrian versus automobile oriented neighborhoods. *Transport Policy* 3, 127–141.
- Crane, R., 2000. The influence of urban form on travel: an interpretive review. *Journal of Planning Literature* 15, 3–23.
- Curry, R.W., Jr., 2000. Attitudes toward travel: the relationships among perceived mobility, travel liking, and relative desired mobility. Master's Thesis, Department of Civil and Environmental Engineering, University of California, Davis. Available from: <www.its.ucdavis.edu/publications/2000/RR-00-06.pdf>.
- Feldman, R.M., 1990. Settlement-identity: psychological bonds with home places in a mobile society. *Environment and Behavior* 22, 183–229.
- Frank, L.D., Pivo, G., 1994. Impacts of mixed use and density on utilization of three modes of travel: single-occupant vehicle, transit, and walking. *Transportation Research Record* 1466, 44–52.
- Fry, T.R.L., Harris, M.N., 1996. A Monte Carlo study of tests for the independence of irrelevant alternatives property. *Transportation Research B* 30, 19–30.
- Fujii, S., Kitamura, R., 2003. What does a one-month free bus ticket do to habitual drivers? An experimental analysis of habit and attitude change. *Transportation* 30, 81–95.
- Golob, T.F., Hensher, D.A., 1998. Greenhouse gas emissions and Australian commuters' attitudes and behavior concerning abatement policies and personal involvement. *Transportation Research D* 3, 1–18.
- Hagman, O., 2003. Mobilizing meanings of mobility: car users' constructions of the goods and bads of car use. *Transportation Research D* 8, 1–9.
- Handy, S.L., 1996. Urban form and pedestrian choices: study of Austin neighborhoods. *Transportation Research Record* 1552, 135–144.
- Hanson, S., Schwab, M., 1987. Accessibility and intraurban travel. *Environment and Planning A* 19, 735–748.
- Hensher, D.A., Reyes, A.J., 2000. Trip chaining as a barrier to the propensity to use public transport. *Transportation* 27, 341–361.
- Kitamura, R., Mokhtarian, P.L., Laidet, L., 1997. A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation* 24, 125–158.
- Koppelman, F.S., Lyon, P.K., 1981. Attitudinal analysis of work/school travel. *Transportation Science* 15, 233–254.
- Law, R., 1999. Beyond 'women and transport': towards new geographies of gender and daily mobility. *Progress in Human Geography* 23, 567–588.
- Levine, J., 1999. Access to choice. *Access* (magazine of the University of California Transportation Center) 14 (Spring), 16–19, Available from: <<http://www.uctc.net/access/access.asp>>, accessed 30 July 2003.
- Mokhtarian, P.L., Salomon, I., Redmond, L.S., 2001. Understanding the demand for travel: it's not purely 'derived'. *Innovation* 14, 355–380.
- Næss, P., Røe, P.G., Larsen, S., 1995. Travelling distances, modal split and transportation in thirty residential areas in Oslo. *Journal of Environmental Planning and Management* 38, 349–370.
- Pickup, L., 1984. Women's gender role and its influence on travel behaviour. *Built Environment* 10, 61–68.
- Recker, W.W., Golob, T.F., 1976. An attitudinal modal choice model. *Transportation Research* 10, 299–310.
- Redmond, L.S., 2000. Identifying and analyzing travel-related attitudinal, personality, and lifestyle clusters in the San Francisco Bay Area. Master's Thesis, Transportation Technology and Policy Graduate Group, Institute of Transportation Studies, University of California, Davis. Available from: <<http://repositories.cdlib.org/itsdavis/UCD-ITS-RR-00-08>>.
- Schwanen, T., Mokhtarian, P.L., 2003. Does dissonance between desired and current neighborhood type affect individual travel behaviour? An empirical assessment from the San Francisco Bay Area. In: *Proceedings of the European Transport Conference (ETC)*, 8–10 October 2003, Strasbourg, France. Available from: <www.its.ucdavis.edu/publications/2003/RP-03-18.pdf>.

- Schwanen, T., Mokhtarian, P.L., 2004. The extent and determinants of dissonance between actual and preferred residential neighborhood type. *Environment and Planning B: Planning and Design* 31, 759–784.
- Schwanen, T., Mokhtarian, P.L., submitted for publication. The impact of attitudes toward travel and land use on residential location choice: some empirical evidence from the San Francisco Bay Area. Copy available from: T.Schwanen@geog.uu.nl.
- Schwanen, T., Mokhtarian, P.L., in press. What if you live in the wrong neighborhood? The impact of residential neighborhood type dissonance on distance traveled. *Transportation Research D*.
- Sermons, M.W., Seredich, N., 2001. Assessing traveler responsiveness to land and location based accessibility and mobility solutions. *Transportation Research D* 6, 417–428.
- Srinivasan, S., Ferreira, J., 2002. Travel behavior at the household level: understanding linkages with residential choice. *Transportation Research D* 7, 225–242.
- Turner, T., Niemeier, D., 1997. Travel to work and household responsibility: new evidence. *Transportation* 24, 397–419.
- Van, U.P., Senior, M., 2000. The contribution of mixed land uses to sustainable travel in cities. In: Williams, K., Burton, E., Jenks, M. (Eds.), *Achieving Sustainable Urban Form*. E and FN Spon, London/New York, pp. 139–148.
- Van Wee, B., Holwerda, H., Van Baren, R., 2003. Preferences for modes, residential location and travel behaviour: the relevance of land-use impacts on mobility. *European Journal of Transport and Infrastructure Research* 2.