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Subjective Assessments of Personal Mobility: What Makes the Difference between a Little and a Lot?

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ABSTRACT

Using survey data collected from 1,358 commuting workers in the San Francisco Bay Area in 1998, this paper empirically explores the determinants of individuals' subjective assessments of their mobility (measured on a five-point ordinal scale, for ten different categories of travel). Linear regression was used to identify the relative importance of reported mobility in explaining the variance of the dependent variables. A variety of personal factors were also found to significantly influence such assessments: personality traits, travel-related attitudes, lifestyle characteristics, and affinity for travel. The study provides insight into the way individuals mentally process the amount of travel they do, which will increase our understanding of travel behavior and its motivations.

Keywords: Subjective mobility, travel liking, social cognitive theory.

1. INTRODUCTION

Consider the question “How much do you travel?” Ignoring the possible dilemmas about what one should understand by “travel”, the question would still remain ambiguous. Does it ask about distance? Does it rather inquire about frequency of trips? Does it instead refer to travel time? Each of these interpretations elicits objective, measurable answers to the posed question. It is in objective measures of personal travel such as these where the interest of transportation policy and travel demand modeling usually lies.

There is another legitimate interpretation of the same question. One could answer in terms of a *subjective* assessment of the amount of travel one does. For example, one could respond “I travel a lot”. The association between quantitative reports of mobility and personal qualitative judgments of those amounts is not deterministic: subjective assessments of the same objective amount of personal travel will in general vary across individuals.

Social cognition theory (SCT) assigns a central role to cognitive processes in individuals’ formation of their own realities. People selectively encode environmental stimuli and use personal values, expectations, and beliefs to decide on their actions (e.g. Jones, 1989). As posited by Bandura (1977, 1986, 1989), SCT defines reciprocal relationships between the vertices of a triangle, defined by behavior, environment, and personal characteristics. One side of this triangle bidirectionally links behavior with environment. SCT postulates that individuals’ behavior is affected by environmental factors (e.g. physical constraints, social pressures, opportunities, etc.), but at the same time people’s behavioral choices determine their environment (e.g. the purchase of a certain vehicle may influence the commuting environment; selective attention impacts on the personal definition of the environment). A second link relates the environment with personal fac-

tors. Physical attributes and social circumstances of the environment may influence beliefs. For instance, personal beliefs about a given trip can be affected by the built environment (urban density, road characteristics, scenery, etc.), and the social circumstances (e.g. purpose, number of people, etc.) in which that trip took place. Finally, a link exists between personal factors and behavior. Beliefs and self-perceptions help determine behavioral choices and vice versa. For instance, environmental consciousness and beliefs about amount of personal travel may lead to a reduction in the number of trips by automobile. In the other direction of impact, the number of personal trips can help determine self-perceptions about environmental consciousness and beliefs related to the amount of personal travel done. The relative weight of the links may not be constant though. In some instances, social situations can override well-established attitudes as determinants of behavior, while in other cases, for example when attention is focused inward and external factors are less salient, attitudes can be better determinants of behavior (e.g. Fiske and Taylor, 1984; Bentler and Speckart, 1981).

Our paper focuses on the links from behavior, the environment, and personal factors, to one of the personal factors mentioned above: one's beliefs (expressed as a subjective judgment) about the amount of travel done, which we refer to as Subjective Mobility. We have included measures of behavior, environment, and personal factors that we expect to have some connection with personal transportation, and we test the general hypothesis that Subjective Mobility is affected by these other variables.

What is the importance of studying Subjective Mobility? Most of the research on travel behavior deals with the determinants of actual travel patterns. While the value of this approach is indisputable, we submit that the study of personal evaluations of actual travel is also important. Adopting an excessively behaviorist approach to studying mobility might be misleading. A researcher may

understand a certain number of miles traveled as an objective factual number, whereas the traveler may understand the same number of miles in a different way. To draw inferences from behavior, travel researchers should, ideally, try to see distances traveled through the eyes of the traveler. A number of studies have mapped objective values of travel-related variables (such as travel time or distance, or noise) to individuals' perceived values measured on the same dimension (e.g. Koppelman, 1981; Golledge and Zannaras, 1973; Canter and Tagg, 1975). We are not aware, however, of other studies relating quantitative reports of one's mobility to general qualitative assessments about one's mobility, carrying the judgemental overtones of "a lot" versus "a little". This latter type of mapping may provide additional insight into the individual's frame of mind with respect to the travel she does.

The policy implications are important as well: policy makers may expect people to modify their amount of travel based on the analysts' objective views of those amounts, when in reality they are likely to modify it based on their subjective evaluations of the burden or pleasure a certain type of travel causes for them. Parallel work, using the same dataset, on models of people's desire to increase or decrease their amounts of travel (Choo, *et al*., 2005) lends support to this view. We believe that a better understanding of the concept of Subjective Mobility will have the potential of improving transportation policy, by improving our ability to forecast behavioral responses to transportation policies.

The organization of this paper is as follows. The next section deals with the empirical context of the study, including a brief description of the data and key variables. Section 3 is concerned with the models developed, starting with general specification issues, followed by an overview of the key results. Section 4 presents our summary and conclusions.

2. EMPIRICAL CONTEXT

2.1 Survey Design and Data Collection

The data analyzed in this study come from a fourteen-page self-administered survey mailed in May 1998 to 8,000 randomly selected households in three neighborhoods of the San Francisco Bay Area. Half of the total surveys were sent to the urban neighborhood of North San Francisco and the other half were divided evenly between the suburban cities of Concord and Pleasant Hill. These areas were chosen to represent the diverse lifestyles, land use patterns, and mobility options in the Bay Area. Approximately 2,000 surveys were completed by a randomly selected adult member of the household and returned, for a 25% response rate. In view of the impact of the commute on individual travel patterns, and preliminary analysis indicating substantive differences, in a number of important ways, between commuters and non-commuters, we focus this analysis on the subset of 1,358 respondents identified as workers (part-time or full-time) who commute at least once a month. Table 1 presents descriptive statistics of some of the variables that characterize our sample.

[Table 1 goes about here]

We group the information retrieved by the survey into 10 categories that we call Objective Mobility, Subjective Mobility, Relative Desired Mobility, Travel Liking, Attitudes, Personality, Lifestyle, Excess Travel, Mobility Constraints, and Sociodemographics. In the present study, we assume that Relative Desired Mobility (expressing the desire for less, the same, or more travel in the future) is more likely an effect rather than a cause of Subjective Mobility (a view supported, though not proven, by the significance of Subjective Mobility in the models for Relative Desired Mobility presented in Choo, *et al*., 2005), and thus is not further treated here. However, both directions of causality will be tested simultaneously in future work. The reader may find it con-

venient to refer forward to Table 2, discussed in Section 3, for a list of the remaining variables that end up appearing in the final models.

The questions pertaining to the first four categories had similar structures in the survey. In each of these categories, measures were obtained both overall and separately by purpose and mode, for short-distance and long-distance travel. Consistent with the American Travel Survey (a large-scale government-funded survey of long-distance travel in use at the time of our data collection), long-distance trips were defined as those of 100 miles or more, one way. The short-distance purposes measured in the survey were: commute, work/school-related travel, grocery shopping, to eat a meal, for entertainment/social/recreational activities, and for the purpose of taking others where they need to go. The short-distance modes measured were: personal vehicle, bus, train/ heavy rail/light rail and walking/jogging/bicycling. Long-distance measures were obtained for the work/school-related and entertainment/social/recreational purposes, and for the personal vehicle and airplane modes.

2.2 Variables

This section presents in greater detail our operationalization of the concepts introduced above.

2.2.1. The endogenous variables: Subjective Mobility

The survey measured Subjective Mobility using the following question: “For each of the following categories, circle the number on the scale which best describes how *you* view the amount of travel *you* do.” Only the ends of the five-point scale were semantically labeled, with “none” and “a lot”, respectively, and the question was asked with respect to a total of 16 categories. In view

of time and resource limitations, we judgmentally selected ten of the most important of these measures as dependent variables in individual models: short-distance overall, commute, work/school-related, entertainment/social/recreational, and by personal vehicle; and long-distance overall, work/school-related, entertainment/social/ recreational, by personal vehicle, and by airplane (these variables are enumerated later as the column heads of Table 2).

2.2.2. The exogenous variables

As described in the Introduction, we are interested in how travel behavior, the environment, and personal factors affect Subjective Mobility. It is difficult, however, to categorize the exogenous variables in terms of these three groups, as some of the variables employed lend themselves to interpretations fitting more than one of the groups. We therefore introduce the set of exogenous variables using the study-specific categories discussed in Section 2.1.

Objective Mobility:

The variables within this group are meant to be the operationalization of actual (travel) behavior. We chose the name Objective Mobility to signify that we expect it to be objective quantifications of personal behavior. These questions asked about distance and frequency of travel by mode and trip purpose, as well as travel time for the commute trip (in view of its recurrent nature, its role as an anchor around which other travel behavior is oriented, and its impact on urban congestion, several questions on the survey dealt with the commute trip in greater detail than for other types of travel). For short-distance trips, respondents were asked how often they traveled for each purpose, with six categorical responses ranging from “never” to “5 or more times a week”. Fre-

quency of trips by mode was not obtained, as a survey design economy. Respondents were also asked to specify how many miles they traveled each week, in total and by mode and purpose.

The long-distance Objective Mobility variables come from a section of the survey in which respondents were asked how often they traveled to various parts of the world "last year", by purpose (for entertainment and work/school-related activities) and mode (personal vehicle, airplane and other) combinations, with an "other" category to capture any remaining travel. These responses indicated number of trips directly, and were also converted into approximate distances by measuring from a central position in the Bay Area to a central location within the destination region.

Trips were combined across world regions to obtain initially three different measures of distance:

1. Total miles, the simple sum of the estimated miles for each reported trip.
2. Log of miles, the natural logarithm of one plus the total number of miles. One mile was added to each total so that when zero miles were actually traveled, the log transformation would return the value zero (= ln(1)) rather than $-\infty$ (= ln(0)).
3. Sum of the log-miles, obtained by taking the natural logarithm of one plus the number of miles of each trip *separately*, and summing across all trips. This transformation gives a higher weight to each trip, on the assumption that the number of trips, and not only the total distance, may affect Subjective Mobility (Curry, 2000).

Distinguishing each of these variables by travel mode (personal vehicle, airplane, and other means), plus retaining the original "total" variables, yielded a set of 12 measures of distance, which were eventually used in the models.

These Objective Mobility variables are in fact self-reported like all the other variables in this study (except residential neighborhood), and as such inevitably have a subjective element. In the sense that they are reported on objectively measurable dimensions (miles, trips), they clearly differ from the qualitative assessments that we refer to as Subjective Mobility. However, there is an inherent endogeneity in that individuals' self-reports of Objective Mobility are likely to be influenced by (or simultaneously determined with) their subjective assessments of that mobility (e.g. the person who thinks she travels "a lot" may overestimate her Objective Mobility, and conversely for the one who thinks she travels a little). This endogeneity could only be eliminated by external objective measurement of respondents' actual mobility, which was impractical in view of the budget constraints of this study. We believe it is still of value to examine the influence of perceived or reported Objective Mobility on Subjective Mobility, that is, to explore how individuals would qualitatively characterize a given perceived quantitative amount of travel.

Travel Liking:

This group of variables is our operationalization of affective attitudes toward personal travel. Respondents were asked to rate each of the same categories as for Subjective Mobility, on a five-point scale from "strongly dislike" to "strongly like". Our initial hypothesis was that Travel Liking would have a negative impact on Subjective Mobility: the more I like traveling, the less burdensome it will seem, and the lower the cognitive weight it will have. The results of our analysis (discussed in Section 3) show that this hypothesis was too simple to reflect the complex relationship between the liking for and the subjective assessment of travel.

Attitudes:

The survey contained 32 attitudinal statements related to travel, land use, and the environment, to which individuals responded on the five-point Likert-type scale from "strongly disagree" to "strongly agree". These 32 variables were then distilled, through factor analysis, into six underlying dimensions: travel dislike[1], pro-environmental solutions, commute benefit, travel freedom, travel stress, and pro-high density (for the details of this analysis, as well as the factor analyses on the Personality and Lifestyle variables, see Mokhtarian, *et al.*, 2001). This group thus contains constructs intended to capture the respondents' attitudes toward a variety of issues related to transportation.

Personality:

We developed a set of 17 qualifiers to capture those personality traits that were hypothesized to relate in some way to individuals' travel orientations. Respondents were asked to indicate how well (on a five-point scale from "hardly at all" to "almost completely") each of these qualifiers (such as "variety-seeking", "restless", "like moving at high speeds", and "like staying close to home") described them. We opted for this *ad hoc* approach to measuring respondents' personality because we believed that these more travel-specific constructs, as opposed to standard ones such as introvert-extrovert, would yield more useful and easier-to-interpret results. These 17 attributes reduced to four Personality factors: adventure seeker, organizer, loner, and the calm personality.

[1] The travel dislike attitudinal factor differs from the Travel Liking variables in that the former is a single score derived from ratings of several constituent statements (e.g., "travel is boring"; "the only good thing about traveling is arriving at your destination"; "travel time is generally wasted time"; "I like exploring new places"; and "getting there is half the fun" – the latter two statements negatively associated with the factor), whereas the latter is a sepa-

Lifestyle:

The survey contained 18 Likert-type scale statements relating to work, family, money, status and the value of time. These 18 questions produced four Lifestyle factors: status seeker, workaholic, family/community-oriented and a frustrated factor. This group of variables purports to capture part of the social environment that SCT holds may affect the personal factors in general, and Subjective Mobility in particular.

Excess Travel:

Thirteen statements asked how often (on a three-point scale: "never/seldom"=0, "sometimes"=1, "often"=2) the respondent engaged in various activities that would be considered unnecessary travel or "excess travel" (such as traveling "just for the fun of it", "with no destination in mind", or "to clear your head"). The Excess Travel indicator is the sum of the responses to these statements, ranging from 0 for the respondent who never/seldom did any of them to 26 for the respondent who often did all of them. This variable can be considered an indicator of a limited aspect of Objective Mobility, but also has affective overtones indicating an enjoyment of travel beyond the purely utilitarian.

Mobility Constraints:

In our study, Mobility Constraints are physical or psychological limits on travel. These constraints are measured by questions concerning the existence of "physical conditions or anxieties"

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rate set of direct judgements of one's affect for travel, distinguished by distance, mode, and purpose. See Ory and

that limit traveling by certain modes or at certain times of day (with ordinal response categories "no limitation", "limits how often or how long", and "absolutely prevents"), and the availability of an automobile when desired. This group of variables captures part of the external (and internal) environment affecting respondents' personal factors.

Sociodemographics:

The Sociodemographic variables include neighborhood type (North San Francisco=urban, other=suburban) and vehicle type dummies, gender, age, years in the U.S., education and employment information, and household information. These variables also operationalize aspects of the physical and social environments, but in addition they may serve well to represent internal characteristics of the respondent (for example, through education).

3. ANALYTICAL METHOD AND RESULTS

3.1 General Model Specification Issues

Linear regression models were developed for the 10 dependent Subjective Mobility variables, and estimated using ordinary least squares (OLS) regression. As explained further in Section 3.2, we chose to present OLS models mainly because they allowed us to better explore and quantify the relative importance of Objective Mobility as a determinant of Subjective Mobility. We also estimated ordered probit models for the same endogenous variables, which yielded essentially identical results in terms of the significant explanatory variables. Stepwise regression was used to refine initial trial specifications, allowing numerous explanatory variables to enter the models. Explanatory variables were incorporated whenever their *F*-probability was 0.05 or lower

Mokhtarian (2005) for further discussion.

and were released whenever the same indicator was bigger than 0.1. (The *F*-probability refers to the chance of being wrong if one concludes that a given variable is significant in the model. When this probability is small, the variables should be retained, if the indicated relationship is conceptually plausible).

3.2 Key Results

This paper focuses on identifying the factors that influence individuals' subjective assessments of their mobility. Therefore, we do not concentrate on the specific interpretation of each model (which can be found in Collantes and Mokhtarian, 2002). The results of the models are therefore presented in summary form in Table 2, indicating the variables that entered each model and the sign of their corresponding coefficient. The adjusted R^2s obtained for the models range from 0.21 for long-distance entertainment/recreation/social Subjective Mobility, to 0.42 for long-distance airplane Subjective Mobility. These values are well within the typical range of those found for disaggregate cross-sectional regression models (Greene, 1997, Section 6.5).

In the three subsections below, we first analyze the impact of Objective Mobility on one's assessment of Subjective Mobility. Then, we analyze the impacts of other variables, reserving a discussion of the complex role of Travel Liking for the third subsection.

[Table 2 goes about here]

3.2.1 Role of Objective Mobility

Every model is led by one or (more often) several explanatory variables indicative of the Objective Mobility for the specific context given by the dependent variable. For instance, commute travel perceptions are strongly influenced by the square root of the average commute time and the frequency of commuting. In nearly every case, variables representing both trip frequency and total distance are significant, suggesting that both these measures of Objective Mobility are important to individuals' assessment of their Subjective Mobility. This pattern highlights the strength of the link between behavior and Subjective Mobility as compared with the other two links of the social cognitive triangle. When a person is asked to make a judgment about herself (in this case about her mobility), this judgment may not be readily available, and she may resort to the information that is more accessible to her to construct that judgment. It is expected that personal behavior will constitute the main source of information used in these judgments (Wyer and Carlston, 1979).

Some secondary Objective Mobility variables are usually found, which convey illustrative information regarding lifestyles and sociodemographics. That is, in these cases, behavioral variables are actually used to a certain degree as proxies for personal or environmental factors. These variables improved the model by representing multi-faceted aspects of the individual, including capturing characteristics not contained in our set of four Lifestyle factors (or enhancing some that are). For example, travel to eat meals is indicative of an out-of-home focused lifestyle, and travel to take others where they need to go reflects a family- or community-centered lifestyle.

To investigate the extent of the role played by the Objective Mobility variables in these models, we re-estimated each model in two ways. In the first way, we allowed to enter only the origi-

nally-significant Objective Mobility variables that can be directly related to the Subjective Mobility variable that is modeled. We defined these directly-related Objective Mobility variables as follows:

1. For short-distance Subjective Mobility mode-specific variables, we allow short-distance Objective Mobility overall, the counterpart short-distance Objective Mobility mode-specific variable, and any short-distance Objective Mobility purpose variables.
2. For short-distance Subjective Mobility purpose-specific variables, we allow short-distance Objective Mobility overall, the counterpart short-distance Objective Mobility purpose-specific variable, and any short-distance Objective Mobility mode-specific variables.
3. For the short-distance Subjective Mobility overall variable, we allow any short-distance Objective Mobility variables.
4. For long-distance Subjective Mobility variables we apply criteria analogous to those described in points 1, 2, and 3.

The R^2s for the resulting models (denoted R^2_{OM}) are presented in Table 2, and the proportions of the full-model R^2s that are accounted for by the Objective-Mobility-only models (as defined above) are also presented. These proportions constitute upper bounds for the influence of the indicated Objective Mobility variables on Subjective Mobility, because when some variables are excluded from the original models, the remaining included variables (to the extent that they are correlated with the excluded variables) pick up some of their explanatory power.

Secondly, we re-estimated each model *excluding* the originally-significant Objective Mobility variables, and subtracted the resulting $R^2_{non\text{-}OM}$ from R^2_{full} to obtain another measure of the

impact of Objective Mobility on Subjective Mobility. The latter approach constitutes a lower bound for the contribution of Objective Mobility, since the included non-Objective-Mobility variables will be picking up some of the explanatory power of the excluded Objective Mobility variables with which they are correlated. These lower-bound measures are also presented in Table 2, together with the proportion they represent of the respective R^2_{full}.[2]

The results show that Objective Mobility may indeed carry the bulk of the explanatory power for these models, with proportions ranging from 0.13 and 0.35 (lower and upper bound, respectively, for long-distance entertainment/recreation/social) to 0.13 and 0.95 (for short-distance work/ school related). The lower-bound contribution of Objective Mobility exceeded 50% of the explained variance in only two out of the 10 models estimated, but if the midpoint between the lower and upper bounds is taken as the contribution, the Objective Mobility contribution exceeded 50% in eight of the models. On the other hand (again taking the midpoint as the contribution), Objective Mobility *fails* to account for between one-fourth and three-fourths of the explained variance, indicating that controlling for Objective Mobility leaves a substantial proportion (44%, on average) of explained variation in Subjective Mobility to other variables.

3.2.2 Role of Other Variables (Except Travel Liking)

The vehicle type dummy variables repeatedly appeared in the results. This is a clear indication that vehicle type influences one's judgments of mobility. Interestingly, none of these variables

[2] This analysis of the contribution of Objective Mobility to the explanatory power of the models is the primary reason for reporting the OLS results rather than the ordered probit ones. Although we could have presented a similar set of outcomes using log-likelihoods and/or pseudo-R^2 measures for ordered probit, such measures are less well-known and -understood than R^2s for OLS, and there is not unanimity with respect to the optimal measure (Veall and Zimmerman, 1992).

appear in the model for the perception of short-distance travel by personal vehicle, which suggests that the role of vehicle type in molding perceptions is related to particular trip purposes.

The adventure-seeker Personality factor and the Excess Travel indicator frequently entered the models, consistently elevating mobility perception. People with high scores on these variables are likely to engage in substantial amounts of objective travel, which will in turn elevate their Subjective Mobility. However, since Objective Mobility is theoretically controlled-for (although these variables may be capturing some residual non-linear influence of Objective Mobility), we argue in addition that these people have a higher enjoyment of the travel experience. Further, "traveling" is likely to be a very important concept in the self-image of these people. Thus, their cognitive processes are likely to be influenced by a drive to satisfy their self-image.

The educational background and income level seem to interact to influence mobility perception in an interesting way. These variables, and related proxies like the year of the personal vehicle, tend to deflate mobility perception of short-distance travel, while they inflate it for long-distance travel. In the case of commute and probably overall travel, we attribute the deflating short-distance effect to the greater ability of higher-income, better-educated people to focus on a fulfilling job and thereby minimize the psychological effect of the commute required to reach the job. In the case of recreational travel, the effect may be due to the lower relative cost of such discretionary travel to higher-income people compared to lower-income, and also due to the higher relative proportion of long-distance travel for those with higher incomes (given higher amounts of long-distance travel, a certain amount of short-distance travel might feel like less than it would for someone with lower long-distance travel). This negative impact on short-distance mobility perception contrasts with the conventional positive impact that personal income showed on Ob-

jective Mobility (Mokhtarian *et al.*, 2001), and hence illustrates that the two constructs of mobility, while strongly positively related, are by no means synonymous.

It is also interesting to note the variables that are not (or are seldom) significant in the models. The impacts of the travel dislike, travel stress, and commute benefit Attitude factors may be largely captured by the more summary, yet context-specific, Travel Liking measures, which are quite prominent (as discussed further in Section 3.2.3 below). The calm Personality and status-seeker Lifestyle factors may be more fundamental constructs that contribute to explaining variables such as Travel Liking, Objective Mobility, and income, but that do not exert an independent influence on Subjective Mobility once those intermediate variables are included.

Mobility Constraints are rarely significant, which may mean that they are not salient enough to a large enough group of people to appear in a model for the population as a whole, and/or may mean that individuals' assessments of their mobility constraints are more a function of their personal characteristics than of their travel behavior. Finally, the neighborhood type indicator is never significant. Since that variable is certainly correlated with many of the Sociodemographic and other variables in the data set (Schwanen and Mokhtarian, in progress), it is reasonable to conclude that any influence it might have on Subjective Mobility is more directly captured by the other variables in the model.

3.2.3 Effects of Travel Liking on Subjective Mobility

Travel Liking is actually an attitude — specifically an affective attitude toward traveling (Ory and Mokhtarian, 2005). Thus, our dataset provides information about attitudes toward traveling specific to modes and purposes. Travel Liking variables are explicitly significant to the corre-

sponding measure of Subjective Mobility in seven out of 10 models (the pertinent cells in Table 2 are crosshatched). We argue, further, that the corresponding Travel Liking variable is implicitly significant in the model for short-distance work/school-related Subjective Mobility[3].

Our original set of models contained Travel Liking only as a straightforward linear term. Although our preliminary hypothesis was that Travel Liking would have a negative impact on Subjective Mobility, we found this to be directly the case for only one model out of 10: the one for commuting. In most of the remaining models, to our initial surprise, Travel Liking entered with a *positive* coefficient. Upon further reflection, we identified two plausible ways in which the effect of Travel Liking could be positive.

First, Travel Liking (through its positive link to Objective Mobility) may be indirectly capturing some of the positive effect of Objective Mobility on Subjective Mobility (the more I like traveling, the more I do travel, and hence the more I perceive I travel). However, we will assume for the sake of the discussion below that Objective Mobility is largely being controlled for (as we believe it to be, in view of the extensive set of Objective Mobility variables significant in the models), so that we are really modeling the impact of Travel Liking on the amount by which a given level of Objective Mobility is stretched or shrunk, so to speak (that is, the impact of Travel Liking on the residual of Subjective Mobility after Objective Mobility is accounted for).

Second, it may well be that the liking for a certain type of travel can also *enhance* (and not only *diminish*) the awareness of that travel. Specifically, we suggest that, theoretically, the Subjective Mobility residual increases when we move to either extreme of the Travel Liking scale. For a

[3] This model includes only the *long-distance* version of the corresponding Travel Liking variable. However, the statistically strong correlation between short- and long-distance work/school-related Travel Liking (0.32) suggests that the latter captures, at least to some extent, the effect we are discussing here.

fixed amount of travel of a certain type, the more one enjoys that particular kind of travel, the more intensely one may experience it, the more readily one may recover those experiences from the memory, and thus the higher one's subjective assessment of that amount of travel will be. (This is not to argue that subjective assessments can be reduced to a memory retrieval process, but rather that memory retrieval is the part of the subjective assessment process that Travel Liking affects). On the other hand, if one dislikes a particular category of travel, the actual travel s/he has to do regardless of that dislike may also intensify the experience and its memory, and increase the subjective assessment of that amount of travel (these ideas are developed further in Ory, *et al*., forthcoming).

The above considerations led us to hypothesize that this Subjective Mobility residual effect might be a U-shaped (tentatively quadratic) function of Travel Liking (as shown in Figure 1), which would explain the observed results. If the true relationship were quadratic but most of the observations *for a given level of Objective Mobility* clustered around the "dislike" end of the Travel Liking scale, a linear fit of Travel Liking to the Subjective Mobility residual would exhibit a negative slope. We would mostly expect such a clustering to occur for mandatory or non-volitional travel, and thus the negative coefficient of Travel Liking that we observed for the commuting model is precisely what would be predicted for that least volitional of the travel categories. (We can point out that 78% of the commuters in our sample disliked or were neutral about commuting, and in this case that supports our point, but just examining Travel Liking in isolation can be misleading, since directly observed measures of Travel Liking will be based on different levels of Objective Mobility and hence be confounding the effects of those two variables on Subjective Mobility).

[Figure 1 goes about here]

Conversely, if most observations for a given level of Objective Mobility clustered around the "like" end of the Travel Liking scale, a linear fit of Travel Liking to the Subjective Mobility residual would exhibit a positive slope. We believe a predominant "liking" to be a common occurrence for the more discretionary or volitional types of travel measured in our data (again, supported but not proven by the raw distributions of the Travel Liking variables, as shown in Ory and Mokhtarian, 2005), and hence this would explain the positive slope of the Travel Liking variable observed in *at least* seven of our 10 original models.

Additional model building offered only a certain amount of direct support for this hypothesis. In the long distance models, including quadratic Travel Liking terms simply replaced the corresponding linear terms (i.e. drove them into insignificance) with the same positive sign. This means that the relationship of Travel Liking to Subjective Mobility was a monotonically increasing one throughout the observed range of Travel Liking (the integers 1-5) since, with no linear term, the minimum of the upward-opening parabola would occur at Travel Liking = 0. Thus, the long distance models with quadratic terms did not reveal a relationship between Travel Liking and Subjective Mobility that was substantially different from the linear models[4], and in fact in two cases the quadratic model had an inferior adjusted R^2. Given these circumstances, the linear Travel Liking variables were kept in the long distance models.

The quadratic Travel Liking terms *did* play an important role in the short distance overall, commute, and personal vehicle models. Both a linear Travel Liking variable with a negative coeffi-

[4] Strictly speaking, of course, the quadratic relationship, even though monotonic, *is* different from the linear one. Specifically, the quadratic relationship implies an increasing marginal impact of Travel Liking in the range of interest; that is, that the impact of one unit of Travel Liking is stronger at the liking end of the scale than at the disliking end. However, given that the goodness-of-fit measures did not markedly improve with the quadratic form in these models, we did not have a strong basis for accepting an increasing marginal impact in these cases.

cient and a quadratic term with a positive coefficient were significant in these models. In these three cases, the parabolas attain their minima at Travel Liking equal to 2.6, 3.9, and 2.2 respectively, meaning that both disliking and liking travel will result in an elevated Subjective Mobility, as (newly) hypothesized. The minimum for the commute model lies on the "like" side of the scale. According to the hypothesis sketched in Figure 1, this result suggests, as expected, that commuting is a *mostly* disliked type of travel. By contrast, the minimum for the other two categories are in the "neutral to dislike" range. It is interesting that these are precisely the two categories likely to be most strongly influenced by the commute travel of the individual. Thus, we can summarize these results by concluding that more-liked categories of travel have a clear positive relationship between Travel Liking and Subjective Mobility, the most-disliked category of travel (commuting) has a largely negative relationship, and the two categories involving a mixture of commuting and other travel show a significant quadratic relationship.

4. SUMMARY AND CONCLUSIONS

Taking social cognition theory as our basic framework, the purpose(s) of this study were (1) to explore the role of different measures of Objective Mobility (trips, distance) in determining one's subjective assessment of mobility, and (2) to explore why two people with identical objective amounts of travel would have different subjective ("a little", "a lot") evaluations of those amounts. Although other studies have explored individuals' perceptual distortion of quantitative measures of specific trips on the same quantitative scale (e.g. perceived distance or travel time), to our knowledge this is the first in-depth study of people's subjective assessments of their travel in a more general sense. Using regression models estimated on survey data collected from 1,358 commuting workers in the San Francisco Bay Area in 1998, this paper empirically explores the

determinants of individuals' subjective assessments of their mobility (measured on a five-point ordinal scale, for ten different categories of travel).

Adjusted R^2s for the models ranged from 0.21 to 0.42. As expected, (reported) Objective Mobility measures carried the greatest explanatory weight, accounting for as much as 35 to 95% of the variance explained. Interestingly, based on best guesses for the incremental contribution of Objective Mobility to overall R^2 values (the midpoints of the bounds presented in Table 2), that contribution was highest for the short-distance obligatory categories of travel (work/school-related and commute) and lower for more discretionary types of travel (notably long-distance entertainment/recreation/social). Measures of trip frequency and distance traveled were significant in most models, indicating that both types of indicators of Objective Mobility influence one's judgment of mobility.

Also as expected, the strong influence of Objective Mobility is moderated by a variety of subjective factors: personality traits, travel-related attitudes, lifestyle characteristics, and affinity for travel. Quadratic forms of this affinity were significant in some of the models, indicating a dual effect of the liking for travel on the subjective assessment of personal mobility. For a given amount of a certain type of travel, this duality can be interpreted in the following way. On the one hand, the more one enjoys that particular kind of travel, the more intensely one may experience it, the more readily one may recover those experiences from memory, and thus the higher one's subjective assessment of that amount of travel will be. On the other hand, if one dislikes a particular category of travel, the actual travel s/he has to do regardless of that dislike may also intensify the experience and its memory, and increase the subjective assessment of that amount of travel.

Our results show considerable correspondence with the tenets of social-cognitive theory, in the sense that social, environmental, and behavioral factors significantly contribute to explain Subjective Mobility. The social environment, characterized by the frustrated, family-oriented, and workaholic Lifestyle factor scores and Sociodemographic variables like household composition, affects Subjective Mobility. The physical environment, as captured by Mobility Constraints and vehicle type, also showed significant explanatory power. Personal factors, here in the form of Travel Liking, Excess Travel, and Personality and Attitudinal factor scores, exhibit strong impacts on Subjective Mobility. In particular we demonstrate that a strong link exists between Travel Liking and Subjective Mobility. One interesting manifestation of such a link is the positive effect of Travel Liking on almost all the measures of Subjective Mobility for the same type of travel. Finally, as already discussed, Subjective Mobility is affected the most by behavior, namely Objective Mobility.

The interplay among Subjective Mobility, Objective Mobility, and Travel Liking found here has important implications for the study of travel behavior, and for plans and policies directed at influencing travel behavior. To find that Subjective Mobility is positively related to Objective Mobility is not surprising: had the study stopped there, it most likely would have been assumed that an elevated Subjective Mobility, indicative of an elevated Objective Mobility, is considered onerous by the individual, who would therefore be inclined to reduce her travel. The results for Travel Liking, however, cast Subjective Mobility in a new light: for travel other than commuting (even for work-related but non-commuting travel), an elevated Subjective Mobility tends to be due to a *liking* for travel. Accordingly, the set of people who travel "a lot" (whether by objective or subjective standards), and who are thus the most strongly targeted by travel reduction approaches, can simplistically be divided into two groups: those who don't like it and those who do, i.e. those who travel so much because they *have* to, and those who do it because they *want* to.

The bases for liking travel for its own sake have been explored elsewhere (e.g. Mokhtarian, *et al*., 2001; Ory and Mokhtarian, 2005; Salomon and Mokhtarian, 1998), and the implications for modeling, planning, and policy are still being worked out (see the Volume 39, Nos. 2-3 special issue of *Transportation Research A*, 2005, for a recent set of papers investigating these issues from a variety of disciplinary perspectives). Here, suffice it to say that those who travel a lot because they like it may have a very different reaction to travel-reducing policies than those who are currently required to travel a lot but would welcome new alternatives giving them more opportunities to cut back. The existence of travel undertaken because it is liked, therefore, also may have complex implications for resource consumption and the environment.

Thus, we argue that Subjective Mobility can be used as a powerful variable to help interpret travel demand, and to help explain the potential *changes* in travel demand when current constraints of various sorts are lifted. The work reported here has provided novel insight into the way individuals mentally process the amount of travel they do. This insight, as refined by further study, will increase our understanding of travel behavior and its motivations. Parallel work on the same data set (Choo *et al.*, 2005) explores the impact of Subjective Mobility on Relative Desired Mobility – individuals' proclivity to increase or decrease their amount of travel. The results further confirm the usefulness of the Subjective Mobility concept to understanding the latent, as well as revealed, demand for travel.

Additional research is needed to better understand the feedback mechanisms that may be at work among Subjective Mobility, Travel Liking, and Relative Desired Mobility, as well as the implications for planning and policy. As an example of the latter, the ways in which we evaluate the

value of travel time savings in monetizing the benefits of transportation improvements may need to be revisited (see Hess, *et al.*, 2005 and Cirillo and Axhausen, 2006).

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List of Tables and Figure

Table 1. Descriptive Statistics for the Study Sample

	Category	Frequency	Percent
Age N = 1354 Mean = 2.55	23 or younger = 1	44	3.3
	24-40 = 2	582	43.0
	41-64 = 3	685	50.6
	65-74 = 4	28	2.1
	75 or older = 5	15	1.1
Sex N = 1349 Mean = 0.49	Female = 0	690	51.1
	Male = 1	659	48.9
Educational background N = 1353 Mean = 4.25	Some grade school or high school = 1	6	0.4
	High school diploma = 2	73	5.4
	Some college or technical school = 3	327	24.2
	4-year college/technical school degree = 4	458	33.9
	Some graduate school = 5	151	11.2
	Completed graduate de-gree(s) = 6	338	25.0
Personal income N = 1324 Mean = 3.406	Less than $15,000 =1	96	7.3
	$15,000 - $34,999 = 2	282	21.3
	$35,000 - $54,999 = 3	404	30.5
	$55,000 - $74,999 = 4	241	18.2
	$75,000 - $94,999 = 5	132	10.0
	$95,000 or more = 6	169	12.8

Table 2. Summary of Effects on Subjective Mobility Assessment

	SHORT DISTANCE					LONG DISTANCE				
	Overall	**Commute**	**Work/School**	**Entertainment**	**Personal Vehicle**	**Overall**	**Work/School**	**Entertainment**	**Personal Vehicle**	**Airplane**
N	1317	1325	1350	1292	1348	1342	1313	1297	1343	1299
R^2_{full}	0.225	0.291	0.391	0.343	0.360	0.309	0.319	0.221	0.231	0.421
Adjusted R^2_{full}	0.217	0.284	0.387	0.333	0.353	0.303	0.313	0.211	0.227	0.415
Upper bound on R^2 due to Objective Mobility variables (R^2_{OM})	0.165	0.242	0.371	0.252	0.298	0.249	0.228	0.078	0.133	0.362
Upper-bound proportion of full-model R^2 due to Objective Mobility variables (R^2_{OM}/R^2_{full})	0.733	0.832	0.949	0.737	0.828	0.806	0.715	0.353	0.576	0.860
Lower bound on R^2 due to Objective Mobility variables ($R^2_{full} - R^2_{non\text{-}OM}$)	0.111	0.189	0.049	0.165	0.099	0.163	0.107	0.028	0.082	0.193
Lower-bound proportion of full R^2 due to Objective Mobility variables [$(R^2_{full} - R^2_{non\text{-}OM})/R^2_{full}$]	0.493	0.649	0.125	0.482	0.275	0.528	0.335	0.127	0.355	0.458
VARIABLE										
Objective Mobility										
Frequency of commute (SD)		+[5]								
Frequency of work/school-related travel (SD)		+	+				+			
Frequency of entertainment travel (SD)				+		+		+		
Frequency of grocery shopping travel (SD)				-						
Frequency of travel going to eat a meal (SD)										+
Frequency of travel taking others where they need to go (SD)					+					
Total trip frequency	+									
Weekly miles in a personal vehicle (SD)	+				+	+			+	
Weekly miles in a bus (SD)					-					
Weekly miles in BART (SD)					-					
Weekly miles walking (SD)					-					

[5] Cells with grey shading indicate impacts of a certain type of Objective Mobility on the same or a related type of Subjective Mobility.

	SHORT DISTANCE					LONG DISTANCE				
	Overall	Commute	Work/School	Entertainment	Personal Vehicle	Overall	Work/School	Entertainment	Personal Vehicle	Airplane
Weekly miles commuting (SD)	+	+	+	-						
Weekly miles of work/school-related travel (SD)			+	-				-		
Weekly miles of entertainment travel (SD)				+				+		
Weekly miles to eat a meal (SD)								+		
Total weekly miles (SD)				+						
Average commute time	+	+						-		
Distance to work		+			+		+			
Number of trips by personal vehicle (LD)	+						+		+	
Number of trips by air (LD)						+	+			+
Miles by PV (LD)										-
Miles by air (LD)				-				+	-	
Log of total miles by personal vehicle (LD)		-		+		+		+	+	
Log of total miles by air (LD)						+	+			+
Miles by other means (LD)						+		+		
Travel Liking										
Overall (SD)	-[6]	+		+						
Overall squared (SD)	+									
Commute (SD)	-	-								
Commute squared (SD)		+								
Work/school-related (SD)										
Personal vehicle (SD)					-					
Personal vehicle squared (SD)					+					
Grocery shopping (SD)				-						
Taking others where they need to go (SD)										+
Overall (LD)						+	-			+
Work/school-related (LD)			+				+			
Entertainment (LD)								+		+
Personal vehicle (LD)									+	-
Airplane (LD)						-				

[6] Crosshatched cells indicate impacts of a certain type of Travel Liking on the same (or the other-distance-category counterpart) type of Subjective Mobility.

	SHORT DISTANCE					LONG DISTANCE				
	Overall	**Commute**	**Work/School**	**Entertainment**	**Personal Vehicle**	**Overall**	**Work/School**	**Entertainment**	**Personal Vehicle**	**Airplane**
Attitudes										
Pro-environmental solutions factor score				-						
Travel freedom factor score								+		
Pro-high density factor score									-	
Lifestyle										
Frustrated factor score					+					
Workaholic factor score				-				-		
Family & community-oriented factor score					+					
Personality										
Adventure seeker factor score	+			+	+	+	+			+
Organizer factor score							+			
Loner factor score			+							
Excess Travel										
Excess Travel indicator				+				+	+	
Mobility Constraints										
Percent of time a vehicle is available	-				+					-
Limitations on walking					+					
Sociodemographics										
Male										-
Age						+				
Years lived in the U.S.				-						
Educational background	-	-						+		
Number of people in the household	+									
Personal income category				-			+	-		+
Household income category								+		
Number of people 6-15 years old in the household										-
Year of the personal vehicle		-								
Vehicle type is compact			-							
Vehicle type is small		+								
Vehicle type is mid-sized	-									
Vehicle type is large		+								
Vehicle type is SUV							-	+		
Vehicle type is van/minivan			+			+			+	

Figure 1: Schematic of Hypothesized and Observed Relationships between Travel Liking and Subjective Mobility