2. Measurement and Marketing Research. Journal of Marketing Research, Vol. 16, Feb. 1979, pp. 1-110.
3. P.E. Green and V. Srinivasan. Conjoint Analysis in Consumer Research: Issues and Outlook. Journal of Consumer Research, Vol. 5, No. 2, Sept. 1978, pp. 103-123.
4. D.J. Reibstein. The Prediction of Individual Probabilities of Brand Choice. Journal of Consumer Research, Vol. 5, No. 3, Dec. 1978, pp. 163-168.
5. M.R. Hagerty. Model Testing Techniques and Price-Quality Trade-Off. Journal of Consumer Research, Vol. 5, No. 3, Dec. 1978, pp. 194-205.
6. R.M. Johnson. Trade-Off Analysis of Consumer Values. Journal of Marketing Research, Vol. 11, 1974, pp. 121-127.
7. E.P. Donnelly, S. Howe, and J. Deschamps. Trade-Off Analysis: Theory and Applications to Transportation Policy Planning. High-Speed Ground Transportation Journal, Vol. 11, No. 1, Spring 1977, pp. 93-110.
8. E.P. Donnelly. Preference Elasticities of Transit Fare Increases and Decreases by Demographic Groups. TRB, Transportation Research Record 589, 1976, pp. 30-32.
9. E.P. Donnelly. Formation and Evaluation of Alternative State Transit Operating Assistance Programs: A Quantitative Preference Technique. New York State Department of Transportation, Albany, Prelim. Res. Rept. 90, April 1975.
10. E.P. Donnelly and others. Statewide Public Opinion Survey on Transit Operating Assistance: Technical Report. New York State Department of Transportation, Albany, Prelim. Res. Rept. 80, April 1975.
11. Market Facts, Inc. Statewide Public Opinion Survey on Transit Operating Assistance: Final Report. New York State Department of Transportation, Albany, April 1975.
12. Peat, Marwick, Mitchell, and Co. Carpooling Impact Study: Technical Memorandum III: Trade-Off Model and Policy Interpretation. U.S. Department of Transportation, Feb. 1976.
13. A.A. Tannir and D.T. Hartgen. Traffic Impacts of Work-Schedule Changes in Medium-Sized Urban Areas. TRB, Transportation Research Record 677, 1979, pp. 58-61.
14. D.L. Weiss. Citizen Opinions on Public Transportation Roles, Service, and Financing. TRB, Transportation Research Record 590, 1976, pp. 5-8.
15. D. Banister. Transport Mobility and Deprivation in Inter-Urban Areas: Interim Report 7. Univ. of Reading, England, 1978.
16. A.A. Tannir and D.T. Hartgen. Who Favors Work Schedule Changes and Why. TRB, Transportation Research Record 677, 1979, pp. 53-58.
17. A.A. Tannir. Impacts of Work-Schedule Changes on Highway Networks, Economics, and Employees. New York State Department of Transportation, Albany, Prelim. Res. Rept. 129, Aug. 1977.
18. A.J. Neveu and K.-W.P. Koeppel. Who Switches to Alternative Work Hours and Why. New York State Department of Transportation, Albany, Prelim. Res. Rept. 162, July 1979.
19. P. Eberts and K.-W.P. Koeppel. The Trade-Off Model: Empirical and Structural Findings. New York State Department of Transportation, Albany, Prelim. Res. Rept. 114, July 1977.
20. A.J. Neveu and K.-W.P. Koeppel. Trade-Off Model: Documentation of Computer Programs. New York State Department of Transportation, Albany, Prelim. Res. Rept. 139, May 1978.
21. R.E. Walpole. Introduction to Statistics. MacMillan, New York, 1974.

Travel-Choice Behavior: Models of Perceptions, Feelings, Preference, and Choice

FRANK S. KOPPELMAN AND ERIC I. PAS

This paper reports on research designed to develop practical methods to assist transportation planners to understand and respond to consumer needs and desires for local travel services. Models that describe the process by which consumers select means of travel based on perceptions, feelings, and preferences are presented and analyzed. These models are operationalized by using factor analysis and multinomial logit estimation. The resultant models describe consumer travel-choice behavior based on perceptions of and feelings toward transit modes and situational constraints. This structure provides diagnostic information that transportation planners can use to modify local service to better serve travel needs and desires.

Effective planning and design of transportation services to meet consumer needs depends on the planner's understanding of consumer travel-choice behavior. This research draws on state-of-the-art knowledge in travel-demand forecasting, consumer behavior theory, and marketing research techniques to develop practical methods that assist transportation planners to understand and respond to consumer needs and desires for travel services. The integration of the knowledge from these disciplines leads to methods of consumer-oriented transportation service planning. This approach provides transportation planners and managers with important diagnostic information about travel behavior that can be used as a guide to formulate strategies that can influence consumers' travel behavior.

The research reported here was conducted in Evanston, Illinois. The transit problems of Evanston are typical of many suburban cities. Significant excess capacity exists on the local public transit system, especially during off-peak hours, and an annual subsidy of $300 000 is required to maintain the transit system. The city of Evanston provides a good context for this research because of its similarity to numerous other suburban communities in the United States.

This research has three main results. First, it

supports previous demonstrations of the importance of perceptions in determining travel-choice behavior (1-5). Second, it extends the range of psychological measures to include feelings about alternatives in addition to perceptions about the performance of the alternatives. Third, it demonstrates the improved interpretation and understanding that can be achieved by use of an intermediate preference stage in the model structure.

THEORY AND MODELS OF MODE-CHOICE BEHAVIOR

Consumers are often presented with the need to choose one of a set of available alternatives. A decision situation arises in the selection of a residence; mode of travel to work; destination for a shopping, recreational, or other trip; etc. Disaggregate travel-demand models, developed in the early 1970s and widely used today, relate travel-choice behavior to objective measures of system performance and demographic characteristics (6,7). As a result, the models provide a limited understanding of the behavioral process underlying travel decision making. Further, because these models exclude measures of travelers' attitudes, including perceptions of service attributes and personal feelings toward different services, they do not reflect the wide range of strategies that can be designed to influence consumer travel behavior.

In recent years, transportation researchers have demonstrated the importance of including measures of service perceptions in travel mode-choice models (1,2,8). It is necessary to draw on theories from psychology, consumer behavior, and marketing in order to fully understand the relationship between system characteristics, perceptions, feelings, preference, and choice.

The focus of this study is to analyze and describe the consumer process for choice of mode for nonwork and nonschool trips to a suburban central business area. The major objective of the research is to examine the relationships between consumers' mode perceptions, feelings, preference, and choice as a basis for understanding consumer mode-choice behavior and developing strategies to modify this behavior. These relationships can be described by the transportation decision-making paradigm (Figure 1) developed at Northwestern University (9) by extending Brunswick's lens model (10,11). In this paradigm, system characteristics (X_i) serve as cues in the formation of consumers' perceptions of service characteristics (Y_j). Each system characteristic is a partial indicator of one or more perceptions. This process of using system characteristics as cues to forming perceptions is called abstraction. Once perceptions are formed, they are aggregated to determine preference. Preference, modified by situational constraints such as mode availability, determines choice. Finally, experience gained by choice and behavior may feed back to modify perceptions. Situational and individual differences not explicitly depicted in this model influence the manner in which individuals form perceptions and aggregate perceptions to direct preference and choice. An important practical implication of this model is that the abstraction and aggregation process should be studied separately and not confused by using system characteristics as direct determinants of preference or choice.

In this study we analyze the relationships among perceptions, feelings, preference, and choice as illustrated in Figure 2. This simplified representation is part of a more complex market process that describes interaction among individuals, information diffusion, changes in behavior based on experience, and differences between market segments (12-14). Nonetheless, the simplified representation provides a useful framework for the analysis of mode-choice behavior.

A particular set of causal links is assumed in this research. Although the relative strength of the causal linkages between attitudes and behavior is the subject of ongoing research (15-17), it appears that the impact of attitudes on behavior is significant. The components of the model structure studied in this research are described briefly in the following paragraphs and in more detail in the sections that follow.

Perceptions of transportation modes are measured by 24 attributes identified by review of the literature, qualitative research, and questionnaire pretesting (18). Factor analysis is used to reduce these transportation service attributes to a smaller set of underlying cognitive dimensions. This provides a simpler perceptual structure that more closely approximates the consumers' use of information in decision making, and it aids managerial interpretation.

Feelings about modes are investigated to determine whether psychological or perceptual factors other than evaluations of mode performance influence transportation preference and choice. A variety of non-performance-related attitudes toward travel alternatives was measured (i.e., affect, personal normative beliefs, social normative beliefs, and extraneous events). These measures are factor-analyzed to develop an aggregate measure of feeling toward each mode.

Preference logit models are used to estimate the importance weights that relate perceptions and feelings to preferences. The estimated importance weights are used to compute a preference index for each individual for each mode. Multinomial logit choice models are used to estimate the influence of the preference index and a particular situational constraint (automobile availability) in determining choice behavior.

PERCEPTION OF MODES

A central hypothesis of this study is that individuals choose among alternatives based on their perceptions of these alternatives rather than on objectively measured characteristics. That is, perceptions of modal attributes (system characteristics) serve as mediating variables between objective measures and preferences. Because formation of perceptions is influenced by both measured (age, income) and unmeasured (experience, psychological make-up) individual characteristics, as well as by modal attributes, perceptions of alternatives differ among individuals.

Consideration of consumer perceptions rather than direct (engineering) measures of alternatives also allows us to include attributes or characteristics for which engineering measures do not exist or that are difficult to obtain. The feasibility and usefulness of incorporating nonengineering measures in models of travel-choice behavior has been demonstrated in numerous studies (1,2,5,8,19). Differences between perceptions among individuals and/or differences between perceived and engineering measures have also been identified (20-24).

Qualitative research techniques were used to identify elemental or fundamental attributes that consumers use to describe local travel modes (18). Consumer ratings of these attributes provide an extensive description of their perceptions. These ratings provide a basis for assessing the relative strengths and weaknesses of each mode. For example, the automobile has the highest average ratings among local travel modes for 20 of 24 attributes rated

Figure 1. Model of consumer transportation behavior.

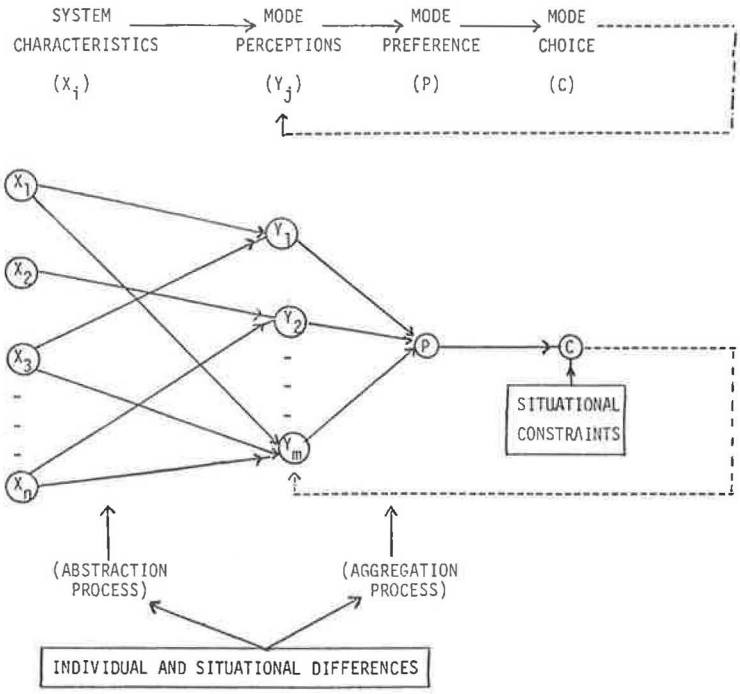
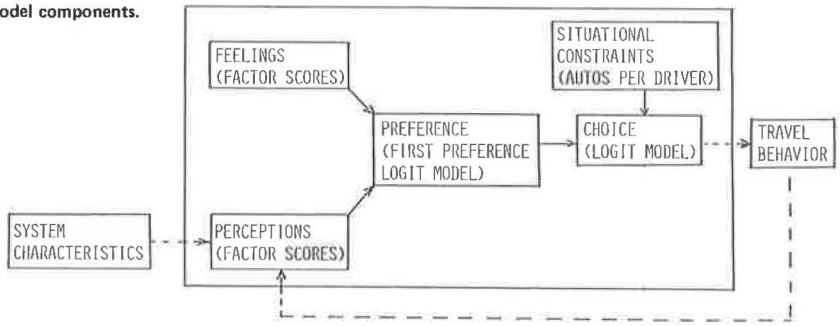


Figure 2. Model components.



(Figure 3). More detailed analyses can be undertaken to examine the relative strength of different ratings and to identify variations in ratings among different groups of respondents (24). These analyses reveal that individuals using bus or walking rate their mode more positively than other individuals, whereas most individuals rate automobile similarly. This is consistent with the findings of Dobson and Tischer (23).

Information on fundamental attributes is cumbersome and difficult for the manager to interpret even when the number of stimuli (modes) is small. Also, research by Bruner and others (25) indicates that consumers identify a relatively small number of basic dimensions to reduce cognitive strain in evaluating products or services. These cognitive dimensions can be identified by factor analysis of the attribute ratings across modes and individuals (26).

Common factor analysis with varimax rotation of 24 fundamental attribute ratings for existing local transport modes was undertaken in two through six dimensions. The three-dimensional solution is selected for further analysis because it captures almost all of the information in perception with respect to its influence on preference and choice. That is, preference and choice models based on perceptions represented in three dimensions have almost identical statistics to those based on four or five perception dimensions (27). This perceptual structure can be used to describe average perceptions of the existing modes. The map of average perceptions in three dimensions (Figure 4) reveals large differences in perception of modes along the general service and convenience or accessibility dimensions and smaller differences between modes for the psychological comfort dimension. The low average rating of car with respect to psychological comfort suggests that car users are expressing a negative response to the strain associated with driving an automobile.

This reduced perceptual map is easier to work with and understand than the fundamental attribute map (Figure 3), which presents too many data to synthesize readily. It also identifies a smaller number of dimensions that trip makers use in evaluating alternative travel modes.

FEELINGS ABOUT TRANSPORTATION MODES

Generally, transportation researchers have employed only one psychological dimension, namely beliefs (or perceptions) about the attributes of the object (e.g., perceptions of the comfort or convenience of transportation modes), in explaining consumers' travel behavior. However, theory and research findings in social psychology indicate that other psychological dimensions might be important

Figure 3. Average attribute ratings: three modes.

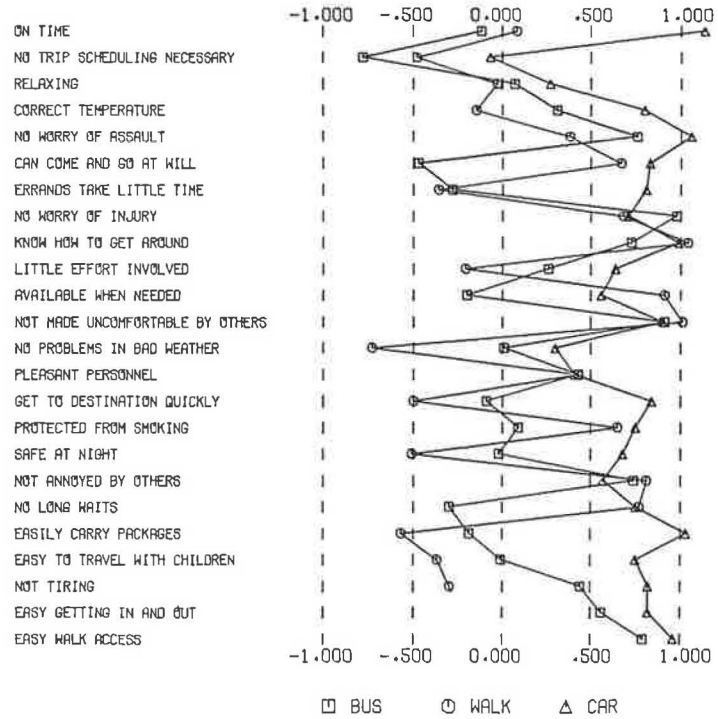
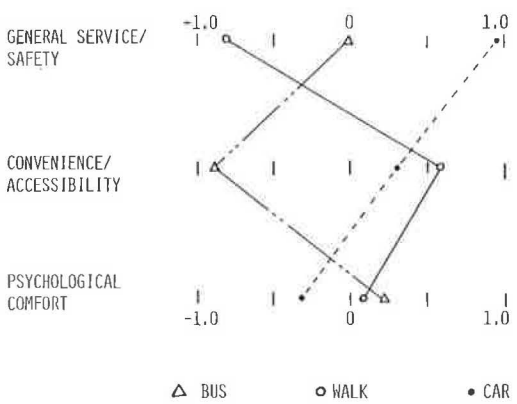


Figure 4. Average mode perceptions in three dimensions.



determinants of travel behavior.

An individual's attitude toward an object is influenced not only by his or her beliefs about the characteristics of that object but also by his or her liking or disliking of the object (affect) (28). Fishbein (29) argued that an individual's attitude toward an object is not the only explanatory variable with respect to behavior. He found that social normative beliefs, i.e., an individual's perceptions of what others want him to do, are important in explaining behavior. Similarly, Schwartz and Tessler (30) demonstrated that an individual's perceptions of what he or she ought to do (personal normative beliefs) also influence behavior. Wicker (31) found level of commitment, i.e., how easily an unanticipated event influences behavior, to be the most important explanatory variable in a study of church-related behavior.

In order to investigate whether any of the above-mentioned constructs influence transportation mode preference and choice, respondents were requested to express their feelings about transportation modes by responding to 27 statements incorporating the above constructs. The statements and their mean standardized scores are shown in the table below. High algebraic values indicate agreement with a particular statement.

Feeling Description	Mean Score
Enjoy travel by car	0.73
Enjoy travel by bus	-0.03
Enjoy travel by foot	0.43
Depressing to travel by car	-0.85
Depressing to travel by bus	-0.42
Depressing to travel by foot	-0.69
Ought to travel by car	0.15
Ought to travel by bus	0.11
Ought to travel by foot	0.31
Peers surprised if drove car regularly	-0.67
Peers surprised if rode bus regularly	-0.04
Peers surprised if walked a lot	-0.21
If weather bad, fewer car trips	0.00
If weather bad, fewer bus trips	0.35
If weather bad, fewer walk trips	0.98
If gasoline price doubled, more car trips	-0.89
If gasoline price doubled, more walk trips	0.50
If gasoline price doubled, more carpool trips	0.04
If gasoline price doubled, fewer car-alone trips	0.65
If bus fares lower, more trips by bus	-0.08
If bus fares lower, fewer trips by car	-0.16
If bus ran more often, more bus trips	0.28
Would travel by car regardless of cost	-0.35
Would travel by bus even if long walk	-0.55
If parking cost doubled, would walk	-0.20
Willing to carpool some trips	0.41
Different from bus riders	0.21

A number of interesting observations may be made from these results. Respondents on average express very positive affect toward car (positive enjoyment, not depressed), less positive affect toward walking, and relatively neutral affect toward bus. They indicate a high degree of sensitivity to major

Table 1. Factor loadings for disposition ratings.

Feeling Description	Cognitive Dimensions		
	Walk Disposition	Bus Disposition	Car Disposition
Enjoy travel by car	-0.32	-0.02	0.61
Enjoy travel by bus	-0.14	0.62	0.14
Enjoy travel by foot	0.73	0.03	0.12
Depressing to travel by car	0.13	-0.15	-0.72
Depressing to travel by bus	0.00	-0.61	-0.30
Depressing to travel by foot	-0.64	-0.15	-0.31
Ought to travel by car	-0.51	-0.21	0.33
Ought to travel by bus	0.03	0.48	-0.06
Ought to travel by foot	0.70	-0.07	0.01
Peers surprised if drove car regularly	0.17	0.15	-0.23
Peers surprised if rode bus regularly	-0.11	-0.58	0.05
Peers surprised if walked a lot	-0.66	-0.16	0.09
If weather bad, fewer car trips	-0.08	0.11	-0.20
If weather bad, fewer bus trips	-0.19	-0.34	-0.05
If weather bad, fewer walk trips	-0.22	-0.05	0.03
If gasoline price doubled, more car trips	-0.26	-0.21	0.11
If gasoline price doubled, more walk trips	0.69	-0.03	0.05
If gasoline price doubled, more carpool trips	0.14	0.11	0.27
If gasoline price doubled, fewer car-alone trips	0.13	0.21	0.13
If bus fares lower, more trips by bus	0.08	0.55	-0.27
If bus fares lower, few trips by car	0.06	0.53	-0.27
If bus ran more often, more bus trips	0.20	0.33	-0.21
Would travel by car regardless of cost	-0.41	-0.42	0.29
Would travel by bus even if long walk	0.11	0.44	0.03
If parking cost doubled, would walk	0.41	0.04	-0.02
Willing to carpool some trips	0.05	-0.01	0.29
Different from bus riders	0.00	-0.31	-0.03

Table 2. First-preference logit models.

Variable	Model 1, Perceptions		Model 2, Perceptions Plus Feelings	
	Parameter Estimate	t-Statistic	Parameter Estimate	t-Statistic
General service and safety	1.92	9.81	1.58	7.54
Convenience or accessibility	0.64	4.54	0.46	3.15
Psychological comfort	0.28	2.35	0.14	1.11
Car feelings			0.26	2.32
Bus feelings			0.50	3.64
Walk feelings			0.65	3.72
Bus constant	-0.33	-1.27	-0.68	-1.78
Walk constant	0.58	2.04	-0.27	-0.55

increases in gasoline prices (fewer car trips, more walk trips), but little sensitivity toward lower bus fares. On the other hand, they express a positive reaction toward improved bus service (more frequent service). Respondents indicate a willingness to carpool for some trips and to reconsider the predominant use of car in the event of cost increases. Thus, in general, respondents indicate a low level of commitment to existing travel choices. As regards personal normative beliefs, respondents generally feel they ought to travel by foot rather than by car or bus. At the same time, most respondents do not feel their peers would be surprised if they drove a car regularly.

These 27 measures were factor-analyzed in three dimensions to develop a composite index of general feelings toward each of the three modes. The three-factor solution identifies a feeling (or disposition) toward each of the three existing local modes of bus, walking, and car. The factor loadings from this solution are presented in Table 1. A factor score for each mode and individual was computed from the factor-score coefficients for the three-dimensional solution to be used in estimation of preference and choice models.

PREFERENCES AMONG MODAL ALTERNATIVES

Model Structure

The conceptual model illustrated in Figure 1 describes the consumer response process in terms of (a) the formation of perceptions about and feelings toward modes, (b) preference formation based on perceptions and feelings, and (c) choice of mode based on preference and situational constraints.

Preference analysis is used to estimate the relative importance of the various perception and feelings measures in the formation of preference for the modal alternatives. The objective is to find a function that maps consumer perceptions and feelings to a preference index that ranks the alternatives consistently with respect to consumer preference (independent of availability and situational constraints). The relative-importance weights are determined by estimating a linear compensatory model in the context of the first-preference logit model. The first-preference logit model estimated in this research has the following general form:

$$P_{ij} = \exp[V(X_{ij}, f_{ij})] \Big/ \sum_k \exp[V(X_{ik}, f_{ik})] \quad (1)$$

where

P_{ij} = probability that individual i ranks alternative j as his or her first preference,
X_{ij} = attributes of alternative j as perceived by individual i,
f_{ij} = feelings of individual i toward alternative j, and
$V(\ )$ = the observed (or measured) portion of the preference rating function.

The appeal of this model is that it explicitly accounts for stochastic behavior (32) and that it does not make metric assumptions about preference rankings. Its drawbacks are that it uses only first-preference information and that it estimates average (i.e., across a group of individuals) rather than individual importance weights. Therefore, additional analyses were undertaken by using a rank-preference logit model (33). These analyses produced results that are similar to those obtained by the first-preference analysis about importance weights, interpretability, and prediction (27).

Model Estimation and Interpretation

Estimated model parameters, standard errors of estimate, and goodness-of-fit statistics for first-preference logit models based on perceptions only (model 1) and on perceptions plus feelings (model 2) are reported in Table 2. All three mode-performance dimensions are significant in the perceptions-only model. General service is most important, followed by convenience or accessibility and psychological comfort. Perceptions of general service and convenience or accessibility and all three mode-specific feelings measures are significant in the perceptions-plus-feelings model.

Table 3. Preference-index and revealed-preference choice models.

Variable	Model 3, Preference Index			Model 4, Revealed Preference		
	Parameter Estimate	t-Statistic	Normalized Importance Weight[a]	Parameter Estimate	t-Statistic	Normalized Importance Weight[a]
General service and safety	2.29	10.61	0.44	0.91	5.09	0.34
Convenience or accessibility			0.13	0.80	5.23	0.29
Psychological comfort			0.04	-0.06	-0.52	0.02
Car feelings			0.07	0.19	1.68	0.07
Bus feelings			0.14	0.17	1.51	0.06
Walk feelings			0.18	0.58	3.30	0.21
Bus constant				0.51	1.34	
Walk constant				-0.72	-1.29	
A/D	0.90	4.59		0.95	2.88	

[a]Determined from parameter estimates for model 2 in Table 2.

The introduction of the feelings measures produces a highly significant ($p < 0.001$) improvement in the model. Their inclusion does not affect the relative importance among the mode performance variables. The likelihood ratio statistic (χ^2) is 527.6 for model 1 and 565.7 for model 2; the pseudo-R^2 (information) is 54.2 percent for model 1 and 58.1 percent for model 2. These results support the hypothesis that attitude variables other than perceptions of mode performance influence preference for transportation modes. The model that includes mode feelings is selected as the base preference model for further analyses.

The importance weights in model 2 indicate that the perceptions that most affect preference are general service and safety and convenience or accessibility. Therefore, to have major impact on preference, strategies should be directed at these dimensions. Alternatively, since bus is perceived best whereas car is perceived worst on the psychological comfort dimension (see Figure 4), persuasion strategies might be directed at increasing this dimension's importance to consumers. Motivation might entail stressing the importance of getting to one's destination without the hassles of driving, as in Greyhound's "leave the driving to us" approach.

CHOICE OF TRAVEL MODE

Model Structure

The conceptual model states that, because of situational and availability constraints, consumers do not always choose the transportation mode that they most prefer for a particular trip. (Approximately 24 percent of the respondents chose other than their most-preferred alternative for their most recent trip to downtown Evanston for nonwork and nonschool purposes.) For this reason, we developed mode-choice models in addition to the preference models reported above. The choice model postulates that individuals associate a value with each alternative and select the alternative that has the greatest value index. The individual value index for an alternative is a linear combination of the preference index and variables that reflect availability or situational constraints. We estimate the parameters of the value index by using the multinomial logit model (34).

One major difference exists between the models reported here and the multinomial logit models commonly used in transportation literature. In other choice models, the weights of the parameters for variables influencing preference and choice are estimated simultaneously on the hypothesis that they are revealed by the choice decision. However, based on our conceptual model (Figures 1 and 2), the intermediate-preference index is computed for each individual (and mode), and this index is used along with situational constraints in predicting choice. Thus, the relative importance of perceptions and feelings is based on reported preference, rather than preference as revealed by choice.

The advantage of estimating importance weights by use of the conventional revealed-preference choice model is that it relies on observed or reported choice behavior rather than on reported preference data. The drawback of the revealed-preference approach is that the estimates of the importance weights for the perceptions and feelings measures may be biased if the nonpreference choice elements are not carefully specified. Such bias would occur if an omitted constraint variable were correlated with a preference variable. For example, distance to the nearest bus stop is a possible constraint not incorporated in the choice models developed in this research. However, this constraint is likely to be highly correlated with the perceptual dimension for convenience or accessibility. Thus, the parameter estimates for perceptions and feelings could be biased in the revealed-preference formulation.

Model Estimation and Interpretation

The situational constraint used in this study is the number of automobiles per licensed driver in the household (A/D). This variable is a measure of the availability of the car mode. We compare our hypothesized preference-index choice model (model 3) with the more-conventional revealed-preference choice model (model 4) in Table 3.

In the preference-index choice model, the relative values of the parameters for mode perceptions and feelings are constrained to equal the importance weights obtained in model 2 (Table 2). Thus, the preference-index model (model 3) has seven fewer degrees of freedom than the revealed-preference model (model 4). Because of this, we expect that the revealed-preference model will have better, but not significantly better, goodness of fit to the data.

The revealed-preference model fits the data significantly better than the preference-index model at the 2.5 percent level. However, the revealed-preference model obtains nonsignificant parameters for three variables (psychological comfort, car feelings, and bus feelings) that theory suggests are important in the mode-selection process. A/D is statistically significant in both models. This supports our hypothesis about the influence of situational constraints on mode-choice behavior. The likelihood ratio statistic (χ^2) is 464.2 for model 3 and 481.6 for model 2; the pseudo-R^2 (information) is 50.4 percent for model 3 and 52.3 percent for model 4.

Given these results, we select the preference-index model to describe the travel mode-choice decision process. This model correctly predicts 80 percent of all trip choices and explains 52 percent of the information in the data set (35). This compares favorably with random or equally likely models (33 percent correctly predicted, 0 percent information) and a market shares model (50 percent correctly predicted, 29 percent information).

SUMMARY

This paper describes the application of a consumer-oriented paradigm of transportation decision making to the development of travel mode-choice models in the context of nonwork and nonschool trips to downtown Evanston. This paradigm provides an improved understanding of consumer travel behavior by inclusion of important attitudinal variables. The consumer-oriented approach described here also provides important diagnostic information about travel behavior, thus assisting in the development of appropriate strategies.

Underlying the proposed methodology is a conceptual model of the interrelationships between system characteristics, perceptions, preference, constraints, and choice. The conceptual model is operationalized in the form of interrelated component models of perceptions, feelings, preference, and choice (Figure 2). The analysis produces powerful mode-preference and mode-choice models based on measures of perception and feelings as explanatory variables. The research indicates that psychological measures of mode feelings, as well as perceptions of mode performance, are important in consumers' preferences for and, hence, choice of travel modes. This has important implications for strategy development, since it implies that preference (and thereby choice) can be altered without necessarily changing the service. Alternatively, it may suggest that changes in mode use in response to service improvements may be limited if deep-seated feelings about modes are not changed.

The conceptual model developed in this research considers choice to be determined by preference and situational constraints, such as car availability. In other words, certain constraints are considered to mediate between preference and choice. This concept is operationalized by using a preference index and a measure of car availability (A/D) in a preference-index choice model. In this analysis, the preference-index model yields statistics similar to those of the more conventional revealed-preference model but provides better understanding and interpretation of the travel choice process.

ACKNOWLEDGMENT

The research reported here was conducted under a U.S. Department of Transportation contract. The invaluable contributions of the other members of the Consumer-Oriented Transportation Service Planning Group, including Alice M. Tybout, John R. Hauser, Patricia K. Lyon, and Kenneth J. Wisniewski, are gratefully acknowledged.

REFERENCES

1. B. D. Spear. The Development of a Generalized Variable for Models of Mode Choice. Cornell Univ., Ithaca, NY, Ph.D. dissertation, 1974.
2. G. C. Nicolaidis. Quantification of the Comfort Variable. Transportation Research, Vol. 9, No. 1, Feb. 1975, pp. 55-66.
3. W. W. Recker and T. F. Golob. An Attitudinal Modal Choice Model. Transportation Research, Vol. 10, No. 5, 1976, pp. 299-310.
4. T. F. Golob, A. D. Horowitz, and M. Wachs. Attitude-Behavior Relationships in Travel Demand Modelling. 3rd International Conference on Behavioral Travel Modelling, Tanunda, South Australia, 1977.
5. F. S. Koppelman and J. R. Hauser. Destination Choice Behavior for Non-Grocery-Shopping Trips. TRB, Transportation Research Record 673, 1978, pp. 157-165.
6. Charles River Associates. A Disaggregate Behavioral Model of Travel Demand. Federal Highway Administration, 1972.
7. M. E. Ben-Akiva. Structure of Passenger Travel Demand Models. Massachusetts Institute of Technology, Cambridge, MA, Ph.D. dissertation, 1973.
8. J. N. Prashker. Development of a Reliability of Travel Modes' Variable for Mode-Choice Models. Department of Civil Engineering, Northwestern Univ., Evanston, IL, Ph.D. dissertation, 1977.
9. Consumer-Oriented Transportation Service Group. Consumer Analysis and Strategies: Final Report of Research into Consumer-Oriented Transportation Service Planning. Transportation Center, Northwestern Univ., Evanston, IL, 1977.
10. E. Brunswick. The Conceptual Framework of Psychology, Univ. of Chicago Press, Chicago, 1952.
11. K. R. Hammond. Inductive Knowing. In The Psychology of Knowing (J. R. Royce and W. W. Roseboon, eds.), Gordon and Breach, New York, 1972.
12. D. T. Hartgen and G. H. Tanner. Individual Attitudes and Family Activities. High-Speed Ground Transportation, Vol. 4, 1970, pp. 439-467.
13. C. H. Lovelock. A Market Segmentation Approach to Transit Planning, Modeling, and Management. Proc., 16th Annual Meeting, Transportation Research Forum, Vol. 16, No. 1, 1975, pp. 247-258.
14. J. R. Hauser and F. S. Koppelman. Designing Transportation Services: A Marketing Approach. Proc., 18th Annual Meeting, Transportation Research Forum, Vol. 18, No. 1, 1977, pp. 638-652.
15. T. J. Tardiff. Causal Inferences Involving Transportation Attitudes and Behavior. Transportation Research, Vol. 11, No. 6, Dec. 1977, pp. 397-404.
16. R. Dobson, F. Dunbar, C. J. Smith, D. Reibstein, and C. Lovelock. Structural Models for the Analysis of Traveler Attitude-Behavior Relationships. Presented at 57th Annual Meeting, TRB, 1978.
17. P. K. Lyon and F. S. Koppelman. Dynamic Structural Equation Modeling of Consumer Behavior for Transportation. Presented at meeting of the Operations Research Society of America and the Institute of Management Sciences, Milwaukee, WI, Oct. 1979.
18. J. R. Hauser, A. M. Tybout, and F. S. Koppelman. The Development and Implementation of a Questionnaire to Determine Consumer Wants and Needs: Report 3 of Research into Consumer-Oriented Transportation Service Planning. Transportation Center, Northwestern Univ., Evanston, IL, June 1977.
19. R. Dobson and J. F. Kehoe. Disaggregated Behavioral Views of Transportation Attributes.

TRB, Transportation Research Record 527, 1975, pp. 1-15.
20. P. K. Burnett. The Dimensions of Alternatives in Spatial Choice Process. Geographical Analysis, Vol. 5, No. 3, 1973, pp. 181-204.
21. P. K. Burnett. Time, Cognition, and Urban Travel Behavior. Geografiska Annaler, Series A, Physical Geography [text in English], Swedish Society of Anthropology and Geography, Stockholm, 1978.
22. W. Miklius and K. L. Casavant. Estimated and Perceived Variability of Transit Time. Transportation Journal, Vol. 15, No. 1, Fall 1975, pp. 47-51.
23. R. Dobson and M. L. Tischer. Beliefs About Buses, Carpools, and Single-Occupant Autos: A Market Segmentation Approach. Proc., 17th Annual Meeting, Transportation Research Forum, Vol. 17, No. 1, 1976, pp. 200-209.
24. F. S. Koppelman, J. Hauser, and A. Tybout. Preliminary Analysis of Perceptions, Preferences, Beliefs, and Usage of Transportation Services for Travel To Downtown Evanston: Report 4 of Research into Consumer-Oriented Transportation Service Planning. Transportation Center, Northwestern Univ., Evanston, IL, June 1977.
25. J. G. Bruner, J. Goodnow, and G. R. Austin. A Study of Thinking. Wiley, New York, 1956.
26. R. J. Rummel. Applied Factor Analysis. Northwestern Univ. Press, Evanston, IL, 1970.
27. E. I. Pas and F. S. Koppelman. Models of Consumer Travel Choice Behavior: Report 5 of Research into Consumer-Oriented Transportation Service Planning. Transportation Center, Northwestern Univ., Evanston, IL, 1978.
28. T. M. Ostrom. The Relationship Between the Affective, Behavioral, and Cognitive Components of Attitude. Journal of Experimental Social Psychology, Vol. 5, No. 1, 1969, pp. 12-30.
29. M. Fishbein. Toward an Understanding of Family Planning Behaviors. Journal of Applied Social Psychology, Vol. 2, No. 3, 1972, pp. 214-227.
30. S. Schwartz and R. Tessler. A Test of a Model for Reducing Measured Attitude-Behavior Discrepancies. Journal of Personality and Social Psychology, Vol. 24, No. 2, Nov. 1972, pp. 225-236.
31. A. Wicker. An Examination of the "Other Variables" Explanation of Attitude-Behavior Inconsistency. Journal of Personality and Social Psychology, Vol. 19, No. 1, July 1971, pp. 18-30.
32. F. M. Bass. The Theory of Stochastic Preference and Brand Switching. Journal of Marketing Research, Vol. 11, Feb. 1974, pp. 1-20.
33. R. D. Luce and P. Suppes. Preference, Utility, and Subjective Probability. In Handbook of Mathematical Psychology (R. D. Luce, R. Buch, and E. Galanter, eds.), Wiley, New York, 1965, Vol. 3, pp. 249-410.
34. D. McFadden. Conditional Logit Analysis of Qualitative Choice Behavior. In Frontiers in Econometrics (P. Zarembka, ed.), Academic Press, New York, 1973, pp. 105-142.
35. J. R. Hauser. Testing the Accuracy, Usefulness, and Significance of Probabilistic Choice Models: An Information Theoretic Approach. Operations Research, Vol. 26, No. 3, May-June 1978, pp. 406-421.