CONSUMER ORIENTED TRANSPORTATION PLANNING: AN INTEGRATED METHODOLOGY FOR MODELING CONSUMER PERCEPTIONS, PREFERENCES, AND BEHAVIOR

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Abstract

This paper presents research examining a model of consumer transportation behavior which integrates system characteristics, perceptions, preference, choice and situational constraints. The research findings are used to develop and evaluate strategies designed to increase consumer acceptance of public transportation.

Introduction

Public officials and private citizens alike acknowledge the need for local public transportation. Public transportation is viewed as necessary both to provide mobility to individuals who do not have any private means of transportation and to offer an alternative to private transportation for all individuals. In addition, public transportation is perceived to be desirable because it offers advantages over private transportation in terms of energy efficiency, environmental pollution, and congestion.

However, several observations indicate that individual and community needs are often not well met by existing public transportation systems. Most local transportation services require substantial operating and capital subsidies, while at the same time, have considerable excess capacity, particularly during off-peak hours. Furthermore, the low utilization of public transportation and the attendant prevalence of private auto trips has resulted in traffic congestion, parking problems, and environmental pollution in many communities, and has contributed to national gasoline shortages.

If strategies are to be developed to gain consumer acceptance of public transportation, a clearer understanding of consumer transportation behavior is required. Specifically, research must be undertaken to:

(1) identify and measure consumer perceptions of transportation alternatives and examine how such perceptions are developed. (i.e. their relationship to actual system characteristics),

(2) determine the relationship between consumers' perceptions and their mode preference and choice,

(3) provide a strong test of the relationships established in (1) and (2). This can be done by developing and implementing strategies based on the knowledge accumulated in (1), (2), predicting the impact of these strategies on perceptions, preference and choice and then evaluating their actual impact on these factors.

In this paper the preliminary results of research undertaken to address the above issues is reported. First the relevant literature is reviewed. Then, the research method and results are summarized. Finally, the practical and theoretical findings are discussed and plans for future research are outlined.

The Literature

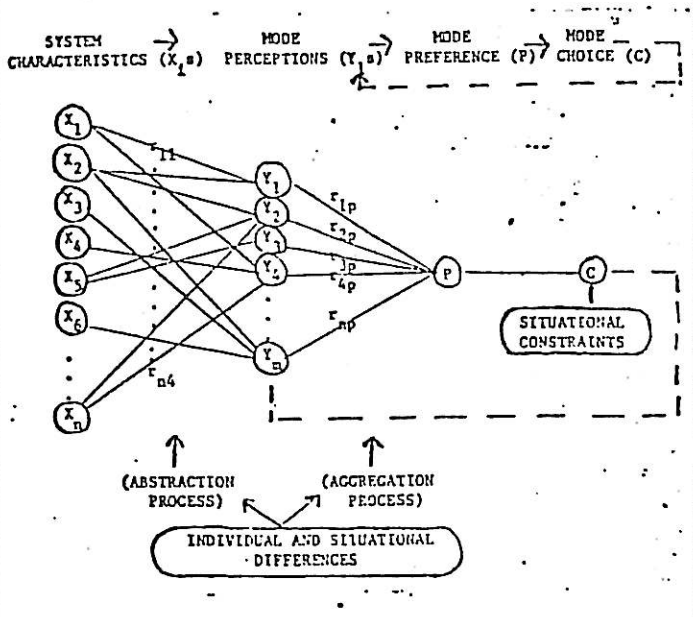
Efforts to understand consumer transportation behavior began in the late 1950's with aggregate studies correlating system characteristics (e.g. travel time, frequency, cost etc.) and community characteristics (e.g. income, education, density etc.) with demand for transportation alternatives (Martin, Memmott, and Bone, 1961; McLynn and Woronha, 1969; Quandt and Banmol, 1966, SARC 1963). Although these models performed well in special circumstances, they did not adequately represent consumer behavior and they gave little guidance for the development of strategies to directly influence such behavior. As a result, disaggregate demand models were developed in the early 1970's to examine the relationships between these variables and mode choice on the level of the individual consumer (Ben-Akvia, 1973; Charles River Associates, 1972; Koppelman, 1975; McFadden, 1970). These disaggregate models, which are still widely used today, lead to a clearer specification of the relationship between system characteristics, consumer demographics and mode choice than did aggregate models. However, like the aggregate models, they concentrate on system and community characteristics. Thus, they fail to provide an understanding of consumers' transportation decision making processes and are not sensitive to the wide set of strategies that can be developed to influence consumer behavior without expensive changes in system characteristics. Additional research is required to gain a better understanding of the consumer and make available the full range of strategic opportunities to community transportation planners and managers.

The critical factor present in consumers' decision making but absent in traditional demand models is consumers' perceptions, which mediate the relationship between system characteristics and mode choice. In recent years several transportation researchers have acknowledged the importance of perceptual variables (e.g. convenience, comfort) and have focused on quantifying these variables so that they can be included, along with system characteristics such as time and cost, in disaggregate mode choice models (Nicolaidis, 1975; Spear, 1976). While this effort to quantify perceptions is important it is not sufficient. An adequate understanding of the relationship between perceptions, system characteristics, preference and choice is also needed.

One way of viewing the interrelationship between system characteristics, perceptions, preference and choice is given by the model of consumer transportation decision making in Figure 1. This model, which is an extension of Brunswik's lens model (see Brunswik, 1952, Hammond, 1966), is similar to models which have been used to describe consumer response to new products/services (Green and Wind, 1975; Hauser and Urban, 1977; Pessemier, 1977). In the model, the system characteristics (x_is) serve as cues used by the consumer in forming his perceptions (i.e. evaluation of convenience, safety, comfort, liking etc.) of the various modes. Each system characteristic is an imperfect indicator of any particular perception and the degree of the association between

these factors is represented by the r_{11}s. Thus, travel time may serve as a partial indicator of convenience for a particular mode. Furthermore, a system characteristic such as travel time may influence several different perceptions in different ways (i.e. travel time may be negatively correlated with convenience but positively correlated with safety). This process of using system characteristics as cues in forming perceptions is called abstraction. Once perceptions are formed they are aggregated to determine choice. A degree of association between the perceptions and preference is represented by the r_{1p}s. Preference, tempered by situational constraints such as mode availability, in turn, directs choice. Finally, choice and experience may feed back modifying mode perceptions. All situational and individual differences not represented in this basic model influence decision making by influencing the manner in which the individual forms perceptions or aggregates perceptions to direct choice.

FIGURE 1
A MODEL OF CONSUMER TRANSPORTATION BEHAVIOR



There are several practical implications of this model. First, if the model accurately represents consumers' transportation decision making, then researchers should concentrate their efforts on understanding the abstraction and aggregation processes (i.e. are linear or non-linear models used etc.) and should not confound these two processes by using both system characteristics and perceptions in one model predicting preference or choice since these variables are likely to be highly correlated. Nor should they develop mode choice models from system characteristics directly. Second, because the model represents the stages in the consumer decision making process it can help the planner or manager diagnose problems in the transportation system. Problems may either be the result of actual system performance, consumer misperceptions of that performance or the importance consumers place on various perceptions. Finally, the model provides an understanding of transportation consumers which can serve as the basis for developing a broad range of strategies to influence consumer mode choice decisions. Using this model strategies which focus on directly altering consumer perceptions or choice may be considered in addition to traditional service modification strategies. For these reasons the model in Figure 1 was used as a basis for the study reported here.

The major objective of our research is to examine the relationships between consumers' mode perceptions, preference, and choice (i.e. the aggregation process) as a basis for developing strategies to modify consumers' choice. We also examine the adequacy of the model in ordering the relationships between system characteristics, perceptions, preference and choice. However, we do not address the abstraction process in this paper since insufficient data was collected to fully investigate it.

The Study

Context

The research was conducted in the city of Evanston, Illinois, in cooperation with the City Manager's Office. Evanston is a northern suburb of Chicago, with a population of approximately 80,000. The Evanston public transit system includes: a rapid transit system which serves Evanston and connects with the Chicago rapid transit system, access to the Chicago Northwestern Railroad which runs directly from the northern suburbs to downtown Chicago, and a local bus service.

The transit problems of the City of Evanston are typical of many suburban cities. Poor public transit service (i.e. variability in lead time and run time, lack of coordination between modes, and a system not tailored to the needs of the community) combined with relatively high auto ownership has resulted in significant excess capacity on the public transit system, especially during off-peak hours. As a result of low ridership and high fixed operating costs, an annual subsidy of $300,000 is required to maintain the transit system. Therefore the City of Evanston provides a good context for research designed to understand consumers' travel behavior and evaluate strategies for increasing public transportation ridership.

Method

Our approach to gaining an understanding of consumer travel behavior entailed developing an instrument for collecting individual data on the variables in the model in Figure 1 and then using this data to test the relationships between these variables and to generate and evaluate strategies designed to alter consumers' behavior. In this section the development of the research instrument and the data collection process are described.

The primary research instrument used was a set of mail questionnaires. Questionnaires were selected for the data collection because they provided the most efficient means of collecting quantitative data on the major variables in the model for a large cross section of the population.[1] The questionnaires were administered by mail because this method allowed us to reach a broader cross section of the population than alternative methods (i.e. telephone or personal interview) and it allowed consumers to respond to the questionnaires, which were quite lengthy, at their leisure.

The development of the questionnaires was a complex, lengthy process. First, input was obtained from three major sources; a usage audit, focus group interviews

[1] However, the use of a questionnaire, especially a mail questionnaire made it impossible to assess actual system characteristics for the respondents at the same point in time as other variables were measured. Instead only perceptions of system characteristics were obtained. A separate study was conducted to explore the relationship between actual and perceived system performance. This study found no significant differences between actual and perceived measures of these factors. Therefore, it appears that these measures can be used interchangeably in this context.

and a review of the literature. The usage audit served to identify the most frequently used modes of transportation for various trip purposes within the community. These frequently used modes were then included in the questionnaires for consumer evaluation (space and time constraints prohibited requesting individuals to evaluate all modes). The focus group interviews and the literature review served to : 1) generate a list of transportation service attributes important to consumers to be used in evaluating modes in the final questionnaire and 2) provice "semantics" so that the questionnaire could be phrased in the language of the consumer. Since these inputs indicated that there were differences in the transportation alternatives available and the relevance of various transportation attributes for different types of trips, three different versions of the questionnaire were developed for each of three major types of trips: trips to work or school, nonwork trips to the CBD, and non-work trips to areas in the city other than the CBD.

On the basis of the focus groups and literature review, scales measuring attributes of transportation services important to consumers were developed and evaluated. This entailed generating an exhaustive list of attributes and then reducing this list to a manageable set of critical attributes (21-25 scales per mode) on the basis of the results of two pretests in which individuals in the community used the attributes to evaluate several modes and also indicated their mode preference and choice. (For more details on the scale development process see Hauser, Tybout, and Koppelman, 1977).

Once the scales were developed, the remaining sections of the questionnaires were drafted and a pretest of the entire questionnaire was conducted. Results of this pretest were used to uncover and correct any problems or omissions in the questionnaire. In addition, the completed pretest questionnaires were used in a preanalysis. This process entailed performing a full-scale statistical analysis on these responses to ensure that the questionnaire provided all the data necessary for the analysis planned on the final questionnaire. A few missing items were discovered and subsequently added, but the most important result of preanalysis was the recognition that mode-specific attributes, popular in the transportation literature, are not compatible with perceptual models unless certain key steps are taken. These steps require that either there be parallel generic attributes for all modes or if attribute has no parallel for a mode (i.e. walk access for the walk mode) there be a clear extreme direction for that mode (i.e. walk access is zero). Based on the pretest and preanalysis the final questionnaires were developed, printed and mailed to a random sample of the target population (1900 work/school trip, 1900 nonwork trip to the CBD and 950 nonwork trip to non-CBD destinations questionnaires were sent.) A follow up post-card was sent to every respondent seven days after the questionnaire mailing, urging them to return the questionnaire.

A summary of the sections of the questionnaire used in the analysis reported here is given below.

(1) system characteristics. Respondents gave estimates of: travel time, broken down by access, wait, and on-vehicle time; bus frequency during rush and non-rush hours; the distance to the nearest bus stop; and bus seat availability. They also provided data which was used to compute auto availability (i.e. they reported the number of drivers and autos in their household).

(2) perceptions. Respondents evaluated each of the three frequently used modes (car, bus, and walk) by responding to 21-25 statements about mode attributes on a 5 point, strongly agree to strongly disagree Likert scale. Respondents also expressed their feelings about each mode in terms of their affect, personal normative beliefs, social normative beliefs and level of commitment by responding to 6-9 statements regarding these factors on a 5 point Likert scale from strongly agree to strongly disagree.[2]

(3) preference. Respondents rank ordered the three modes - bus, auto and walk - in terms of their preference.

(4) choice. Respondents indicated the mode which they had used for their most recent nonwork trip to the CBD and also estimated the frequency with which they had used each of the available modes for similar trips in the past two months.

(5) consumer and situational differences. Participants responded to a battery of demographic questions (i.e. age, income, education etc.) and also described characteristics of their most recent trip to downtown Evanston (i.e. purpose, time of day etc.).

Results[3]

Respondents. Forty-one percent (782 out of 1900) of the individuals who received the nonwork trip to downtown Evanston returned it. Five hundred of these responses were selected for analysis on the basis of completeness of response to the attribute ratings and preference rankings questions. Comparison of the demographic characteristics of this sample with 1970 census data indicated that it was reasonably representative of the Evanston population, although some distinctions did exist (see Koppelman, Hauser and Tybout, 1977, for details on data screening and sample representativeness).

Description of System Characteristics. Although consumers' perceptions of a variety of system characteristics (i.e. travel time, frequency, bus seat availability, bus accessability and auto availability) were measured, some of these variables require special coding before they can be used in the analysis. Therefore, only travel time and car availability are discussed here.

Walk travel time for trips to downtown Evanston was perceived to range between 1-5 minutes and 86-90 minutes, while vehicular travel time for similar trips ranged from 1-5 minutes to 26-30 minutes for car and 1-5 minutes to 56-60 minutes for bus. Car availability ranged between 0.0 auto/driver to 3.0 autos/driver, however 97% had one or less autos/driver.

Description of Perceptions of Mode Attributes. The questionnaire measured consumers' perceptions of three modes - bus, walk, and car passenger or driver - on 25 attributes. Respondents' evaluations of the modes on these attributes are summarized in Table 1.

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[2] Historically, transportation researchers have only focused on one psychological dimension, beliefs about attributes of the object (e.g. perception of mode convenience, comfort etc.). Many other psychological variables have been demonstrated to influence behavior, including affect (an individual's liking-disliking of an object, see Ostrom, 1969), personal normative beliefs (an individual's perception of what he ought to do, see Schwartz and Tessler, 1972), social normative beliefs (an individual's perception of what others [illegible] him to do, see Fishbein, 1972), and level of commitment, (how easily is the individual's intended behavior influenced by unanticipated events, see Wicker, 1971). These perceptions have been included in our questionnaire so that their contribution to the explanation of transportation behavior can be examined.

[3] Analysis of this data set is still in process, therefore these results are preliminary.

TABLE 1
AVERAGE STANDARDIZED ATTRIBUTE RATINGS

	BUS	WALK	CAR
ON TIME	-.12	.08	1.13
NO TRIP SCHEDULING NECESSARY	-.78	-.48	-.07
RELAXING	.85	1.00	.78
CORRECT TEMPERATURE	.31	-.15	.80
NO WORRY OF ASSAULT	.76	.38	1.06
CAN COME AND GO AS I WISH	-.47	.67	.83
INEXPENSIVE	.56	1.10	-.59
ERRANDS TAKE LITTLE TIME	-.28	-.36	.81
NO WORRY ABOUT INJURY	.98	.68	.71
KNOW HOW TO GET AROUND	.73	1.04	.99
LITTLE EFFORT INVOLVED	.26	-.21	.64
AVAILABLE WHEN NEEDED	-.20	.91	.56
NOT MADE UNCOMFORTABLE BY OTHERS	.91	1.01	.90
NO PROBLEMS IN BAD WEATHER	.01	-.73	.30
PLEASANT DRIVERS OR OTHER PERSONNEL	.43	.43	.41
GET TO DESTINATION QUICKLY	-.09	-.50	.84
PROTECTED FROM SMOKING	.09	.65	.75
SAFE AT NIGHT	-.02	-.51	.68
NOT ANNOYED BY OTHERS	.74	.81	.57
NO LONG WAITS	-.30	.77	.75
EASILY CARRY PACKAGES	-.19	-.57	1.03
EASY TO TRAVEL WITH SMALL CHILDREN	-.01	-.37	.75
NOT TIRING	.44	-.30	.82
EASY GETTING IN AND OUT	.56	1.27	.82
EASY WALK ACCESS	.79	1.27	.96

*THE RATINGS WHICH APPEAR IN THIS TABLE WERE STANDARDIZED BY INDIVIDUALS ACROSS STIMULI AND SCALES TO REMOVE ANY TENDENCY OF AN INDIVIDUAL TO USE ONLY PART OF THE RANGE IN THE SCALE. IN ADDITION, ALL NEGATIVELY WORDED SCALES WERE MATHEMATICALLY RESERVED SO THAT HIGHER NUMERICAL VALUES IMPLY BETTER RATINGS.

An examination of the ratings in Table 2 indicates that, in general, car is perceived favorably and outscores bus and walk. However, on cost ("inexpensive") and driver stress attributes ("fear of injury","annoyed by others") car fares less well. In contrast, bus is relatively poorly perceived. It receives high ratings only on cost and stress related attributes and is viewed negatively in terms of service attributes. Walk is rated highly in terms of attributes measuring cost, service availability and environment, but is also seen as time consuming and requiring considerable effort to use.

Factor analysis was used to reduce these 25 transportation service attributes to a smaller set of underlying dimensions. This was done for two reasons: 1) consumers do not actually process information about each of the 25 attributes when making an evaluation or choice regarding transportation alternatives (see Bruner, Goodnow and Austin, 1959). Instead they reduce the information to a smaller more manageable set of factors that capture the essence of the larger set. Thus, a simpler perceptual structure more closely approximates consumers' utilization of perceptual information in decision making. 2) This simpler structure helps managers and analysts better understand consumer processes so that they can formulate strategies to affect the most crucial components of consumer response. And, 3) factor analysis enables the analyst to make dimensions orthogonal, thus reducing multicollinearily and leading to stable coefficients when the dimensions are used in preference and choice models.

Factor analysis of the attribute ratings was undertaken for two through six dimensions using common factor analysis with iterations and varimax rotation. The solutions for the various dimensions were compared on the basis of interpretability, explanatory power and accuracy in predicting preference. On the basis of this analysis the three dimension solution was chosen as the best one.

The factor loadings for the three dimension solution appear in Table 2 and mode perceptions on these dimensions are graphed in Figure 2. The three factors - which have been labeled general service and safety, convenience and accessibility and psychological comfort - account for 45% of the variance in the original attribute ratings. This is consistent with previous studies of this nature (see Hauser and Urban, 1977). As Figure 2 demonstrates, car is perceived most favorably on the general service dimension but is viewed less favorably than alternative modes on the convenience/accessibility and psychological comfort dimensions. Bus is viewed poorly on the general service and convenience/accessibility dimension, but receives the most favorable evaluation on the psychological comfort (i.e. freedom from hassles) dimension. Finally, walk scores extremely poorly on the general service dimension, well on the convenience/accessibility dimension, and moderately well on the psychological comfort dimension.

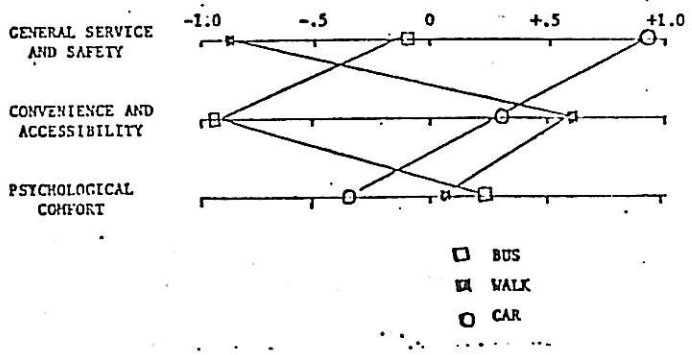
TABLE 2
FACTOR LOADINGS FOR ATTRIBUTE RATINGS

	FACTOR 1	FACTOR 2	FACTOR 3
ON TIME	.57	.40	-.09
NO TRIP SCHEDULING NECESSARY	.26	.27	-.27
RELAXING	.48	.14	.26
CORRECT TEMPERATURE	.58	.01	.11
NO WORRY OF ASSAULT	.48	.00	.30
CAN COME AND GO AS I WISH	.25	.68	-.04
ERRANDS TAKE LITTLE TIME	.69	.29	-.08
NO WORRY ABOUT INJURY	.18	-.07	.47
KNOW HOW TO GET AROUND	.09	.33	.20
LITTLE EFFORT INVOLVED	.69	.09	.21
AVAILABLE WHEN NEEDED	.02	.67	.09
NOT MADE UNCOMFORTABLE BY OTHERS	.06	.22	.54
NO PROBLEMS IN BAD WEATHER	.62	-.03	.14
PLEASANT DRIVERS OR OTHER PERSONNEL	.06	.09	.33
GET TO DESTINATION QUICKLY	.77	.16	-.03
PROTECTED FROM SMOKING	.12	.38	.04
SAFE AT NIGHT	.62	.00	.10
NOT ANNOYED BY OTHERS	.04	.12	.51
NO LONG WAITS	.16	.64	-.03
EASILY CARRY PACKAGES	.71	.13	-.08
EASY TO TRAVEL WITH SMALL CHILDREN	.59	.06	-.08
NOT TIRING	.77	-.00	.19
EASY GETTING IN AND OUT	-.15	.51	.29
EASY WALK ACCESS	-.12	.48	.28

FACTOR INTERPRETATION

FACTOR 1 - GENERAL SERVICE AND SAFETY
FACTOR 2 - CONVENIENCE AND ACCESSIBILITY
FACTOR 3 - PSYCHOLOGICAL COMFORT

FIGURE 2
MODE PERCEPTIONS IN THREE FACTOR SPACE



Description of Feelings About Modes (Perceptions of Factors other than Mode Attributes). In an effort to determine whether psychological or perceptual factors other than evaluations of mode attributes influence transportation preference and choice, a variety of non-attribute perceptions of the three modes were measured (i.e. affect, personal normative beliefs, social normative beliefs, extraneous events). These measures were then factor analyzed to develop an aggregate measure of feelings toward each mode.[4] The factor loadings for the

[4]This approach was taken because each of the original variables was measured by only a few questions per mode and therefore these measures were likely to be unstable if used separately. However, when the variables are combined for each mode they provide a fairly reliable index of a more general feeling toward the mode.

three resulting factors - a car feelings factor, bus feelings factor and walk feelings factor - are presented in Table 1. These factors account for 39% of the variance in the original set of questions.

TABLE 3
FACTOR LOADINGS FOR FEELINGS

	WALK FEELINGS	BUS FEELINGS	CAR FEELINGS
DIFFERENT FROM BUS RIDERS	.05	-.28	.01
ENJOY TRAVEL BY CAR	-.21	-.01	-.55
ENJOY TRAVEL BY BUS	-.12	.71	-.13
ENJOY TRAVEL BY FOOT	.83	.07	-.04
DEPRESSING TO TRAVEL BY CAR	.11	-.06	.76
DEPRESSING TO TRAVEL BY BUS	.04	-.53	.41
DEPRESSING TO TRAVEL BY FOOT	-.67	-.11	.31
PEERS SURPRISED IF RIDE BUS REGULARLY	-.08	-.52	-.06
OUGHT TO TRAVEL BY CAR	-.45	-.19	-.38
OUGHT TO TRAVEL BY BUS	.01	.52	.16
OUGHT TO TRAVEL BY FOOT	.75	-.01	.10
PEERS SURPRISED IF DROVE CAR REGULARLY	.18	.16	.32
IF WEATHER BAD, FEWER CAR TRIPS	-.07	.10	.31
IF WEATHER BAD, FEWER BUS TRIPS	-.14	-.34	.07
IF WEATHER BAD, FEWER WALK TRIPS	-.25	-.03	-.05
IF GASOLINE PRICE DOUBLED, MORE CAR TRIPS	-.30	-.21	-.14
IF GASOLINE PRICE DOUBLED, MORE WALK TRIPS	.69	.06	.16
IF GASOLINE PRICE DOUBLED, MORE CAR POOL TRIPS	.12	.18	.03
IF GASOLINE PRICE DOUBLED, FEWER CAR ALONE TRIPS	.15	.26	.09
PEERS SURPRISED IF WALKED ALOT	-.66	-.11	-.11
IF BUS FARES LOWER, MORE TRIPS BY BUS	.09	.61	.35
IF BUS FARES LOWER, FEWER TRIPS BY CAR	.06	.59	.34
IF BUS RAN MORE OFTEN, MORE BUS TRIPS	.21	.40	.27
WOULD TRAVEL BY CAR REGARDLESS OF COST	-.40	-.39	-.40
WOULD TRAVEL BY BUS EVEN IF LONG WALK	.12	.50	.11
IF PARKING COST DOUBLED WOULD WALK	.44	.04	.21
WILLING TO CAR POOL SOME TRIPS	.06	.09	.00

Preference and Choice. First preference was clearly dominated by car (71% stated this as their first preference), while bus did well in terms of second preference (58% stated bus was their second preference). Consistent with the preference ratings, 66% stated that they had chosen car for their most recent trip. Furthermore, cross-tabulation of first preference and choice data indicated that the vast majority of respondents (76%) chose their most preferred mode. However, it is interesting to note that a significant number of individuals (24%) did not choose their most preferred mode, perhaps due to situational constraints such as availability. This highlights the importance of consumers' second preferences and suggests an area of opportunity for public transportation.

Relationship Between Model Variables. Our model of consumer travel behavior states that the impact of system characteristics on preference and choice is mediated by consumer perceptions. Therefore, system characteristics should be more highly correlated with perceptions of mode attributes than with preference. Examination of Table 4 indicates that this is the case for the travel time variables. Walk travel time is most highly correlated with perceptions of general service (r= -.63) while vehicular travel time is most highly correlated with perceptions of convenience/accessibility (r= -.41). However, auto availability (APD) is highly correlated with not only perceptions of general service, but also preference and choice. This is probably partially attributable to the fact that none of the attribute scales directly measured mode availability. However, auto availability may also have a high correlation with choice because it operates as a situational constraint rather than a system characteristic. If this is the case auto availability is probably best used as a segmentation variable rather than as an independent variable in models predicting perception, preference or choice.

TABLE 4
CORRELATION MATRIX

	SYSTEM CHARACTERISTICS WTT	VTT	APD	ATTRIBUTE PERCEPTIONS GS	C/A	PC	FEELINGS TOWARDS MODES BF	WF	CF	P
WALK TRAVEL TIME (WTT)										
VEHICULAR TRAVEL TIME (VTT)	-.33									
AUTOS/DRIVER (APD)	-.29	.01*								
GENERAL SERVICE FACTOR SCORE (GS)	-.63	.10	.50							
CONVENIENCE/ ACCESSIBILITY FACTOR SCORE (C/A)	.30	-.41	.25	.04						
PSYCHOLOGICAL COMFORT FACTOR SCORE (PC)	-.01*	.01*	-.20	.03*	.04*					
BUS FEELINGS FACTOR SCORE (BF)	.00*	-.14	.00*	.17	.13	.14				
WALK FEELINGS FACTOR SCORE (WF)	-.20	.00	.00*	.31	.10	.11	.00*			
CAR FEELINGS FACTOR SCORE (CF)	.00*	.05	-.06	-.07	-.09	-.13	.00*	.00*		
PREFERENCE (P)	-.28	-.04	.50	.56	.31	-.05	.13	.22	-.11	
CHOICE (C)	-.30	.30	.54	.52	.31	-.09	.13	.17	-.11	.66

*NONSIGNIFICANT AT .05 LEVEL

The perceptual variables (cognitive dimensions and feelings) are viewed as the determinants of preference. Therefore, these variables should be relatively independent and highly correlated with preference. In general these conditions are met. The intercorrelations between these variables are low and they are all significantly related to preference.

Finally, preference and situational constraints are viewed as the determinants of choice. Thus, choice should be highly correlated with these variables. Consistent with this expectation, Table 4 indicates that choice is most highly correlated with preference (r= .66) and next most highly correlated with a situational constraint - auto availability (r= .54). Therefore, we conclude that examination of the correlation matrix provides support for our model of consumer transportation behavior. Next, we will examine the aggregation process posited by this model in more detail.

The Aggregation Process - Preference Models. Preference models based on consumer perceptions were developed. First preference logit was used to statistically estimate the importance weights for the variables in the models. These models, which are presented in Table 5, are summarized below.

In Model 1 the three cognitive dimensions (factor scores) are used to predict preference. The importance weights for these dimensions in this model follow the same pattern as their identification in factor space. General service is the most important variable. Convenience and accessibility is next most important. And, psychological comfort is least important.

In Model 2, the factor scores for respondents' feelings about each mode are added to Model 2. The addition of these variables improves the prediction and explanation of preference by a small but statistically significant amounts ($p < .01$). This finding supports our belief

that perceptual variables other than evaluations of mode attributes influence preference and suggests that efforts to alter preference should consider these variables.

TABLE 5
PREFERENCE MODELS

	FIRST PREFERENCE MODELS	
VARIABLE NAME	(1)	(2)
GENERAL SERVICE FACTOR SCORE	.57	.40 (.68)*
CONVENIENCE/ACCESSIBILITY FACTOR SCORE	.32	.18 (.31)
PSYCHOLOGICAL COMFORT FACTOR SCORE	.11	.01 (.02)
CAR FEELINGS FACTOR SCORE		.08
BUS FEELINGS FACTOR SCORE		.15
WALK FEELINGS FACTOR SCORE		.19
PERCENT PREDICTED	78.1%	80.8%
INFORMATION	53.3%	56%

*WEIGHTS IN BRACKETS ARE STANDARDIZED IMPORTANCE WEIGHTS FOR THE COGNITIVE DIMENSIONS ALONE IN THIS MODE.

In general, the models presented in Table 5 do a good job of predicting first preference. The percent of first preferences correctly predicted by these models are all significantly higher than the percent which would be correctly predicted using a market share model (54.7%) or an equally likely model (33.3%). The information measure reported gives the percent of uncertainty (entropy) explained. This measure is an information theoretic interpretation (Hauser, 1977) of a pseudo R^2 measure (McFadden, 1970). Similar models were developed to predict rank preference using a rank logit model and the rank ordering of variables and interpretation were the same.

Choice Models. Since situational variables as well as preference affect choice a related set of models were developed to predict choice. These models, which were based on the multinimial revealed preference logit formulation (McFadden, 1970) are summarized in Table 6.

Model 1 in Table 6 uses only factor scores for the three cognitive dimensions to predict mode choice. In this model the importance weights for the dimensions were determined in the choice model. This procedure for determining the importance weights was compared to the alternative procedure of using importance weights established in the first preference Model 1. The two models yielded highly similar results. The only difference was the lowered importance of psychological comfort in the choice model. (Future papers will explore this issue further). Since most interpretations were similar for the two procedures and prediction was improved significantly (.05 level) when the importance weights were determined in the choice model, this procedure was used in the models reported here.

In Model 2 the factor scores for feelings about the three modes are added to Model 1. The addition of these three factors improves the prediction and explanation of choice behavior by a small but significant (.01 level) amount.

TABLE 6
MODE CHOICE MODELS

	MODEL	
VARIABLE NAME	(1)	(2)
GENERAL SERVICE FACTOR SCORE	.59	.35
CONVENIENCE/ACCESSIBILITY FACTOR SCORE	.39	.22
PSYCHOLOGICAL COMFORT FACTOR SCORE	.02*	-.05*
CAR FEELINGS FACTOR SCORE		.10
BUS FEELINGS FACTOR SCORE		.18
WALK FEELINGS FACTOR SCORE		.10
PERCENT PREDICTED	77.5%	78.9%
INFORMATION	48.1%	50.0%

*ALL VARIABLES EXCEPT THOSE STARRED ARE SIGNIFICANT AT THE .05 LEVEL

In summary, the choice models in Table 6 generally do an excellent job of predicting mode choice for respondents most recent trip to downtown Evanston. All predictions are substantially better than market share or equally likely models would allow. Models predicting respondents' reported frequency of choice over the last two months were also developed. In general these models were similar to those shown in Table 6.

Segmentation Using Consumer and Situational Characteristics. As depicted in the model (Figure 1), consumer and situational characteristics may influence mode preference and choice by influencing the aggregation process or by influencing choice directly. When these factors have a substantial impact on this process, a clearer understanding of consumer transportation behavior may be obtained by segmenting on these variables and developing separate choice and preference models for each segment.

Two approaches to segmentation may be employed. One approach entails identifying segments in the population on the basis of differences in the descriptive characteristics of individuals (i.e. demographics) or situations (i.e. trip characteristics). An alternative approach involves identifying segments that are behaviorally homogenous and distinct (i.e. segments that respond to transportation alternatives similarly and differently than other segments). In an effort to increase our understanding of consumer transportation behavior we employed both of these approaches to segmentation. First, we examined the impact of segmenting on each of four individual and situational descriptive characteristics - age, education, knowledge of the bus system and auto availability - on the prediction and explanation of mode choice.[5] A Chi square test was used to assess the significance of each basis of segmentation. Only two of the four bases, age and auto availability, were significant. Choice models developed for the subgroups of these significant bases of segmentation are reported in Table 7.

TABLE 7
SEGMENTED CHOICE MODELS

	AUTO AVAILABILITY		AGE		
VARIABLE NAME	LOW[1]	HIGH[2]	UNDER 30	30-59	60 or older
GENERAL SERVICE FACTOR SCORE	.24	.42	.27	.61	.21
CONVENIENCE/ACCESSIBILITY FACTOR SCORE	.20*	.21	.27	.22	.19
PSYCHOLOGICAL COMFORT FACTOR SCORE	.02*	-.08	-.07*	-.05*	-.02*
CAR DISPOSITION FACTOR SCORE	.15	.07*	.17	-.05*	-.07*
BUS DISPOSITION FACTOR SCORE	.24	.15	.09*	.06*	.31
WALK DISPOSITION FACTOR SCORE	.15	.06*	.13	.01	.20*
% CORRECTLY PREDICTED BY SEGMENT	74.3	80.2	80.0	85.1	77.0
INFORMATION BY SEGMENT	51.0	54.0	40.0	63.0	54.0
χ^2 FOR SEGMENTATION	23.5, p<.05		40.6, p<.01		
TOTAL % CORRECTLY PREDICTED	78.9%		81.9%		
TOTAL INFORMATION	53.3%		56.1%		

[1] LESS THAN .5 AUTOS/DRIVER
[2] .5 OR MORE AUTOS/DRIVER

*NONSIGNIFICANT AT THE .05 LEVEL

The choice models for the auto availability subgroups indicate that those with low auto availability place less

[5] Since preference and choice models were highly similar only choice models were examined in the segmentation analysis. Tests of other descriptive bases of segmentation will be conducted in the future.

emphasis on the general services offered by alternative modes and are influenced more by feelings about bus and walk than those with high auto availability. Similarly, the choice models for the age subgroups indicate that individuals under thirty are primarily influenced by the general service and the convenience/accessibility of modes and their negative feelings about car. In contrast the mode choice among middle-aged individuals appears to be primarily determined by general service. The elderly, although significantly influenced by mode attributes (i.e. general service and convenience/accessibility), are most heavily influenced by their feelings about the bus in making mode choice decisions.

An attempt was also made to segment on the basis of individuals' response to transportation alternatives. To identify individuals with similar behavioral responses, a cluster analysis was performed on the factor scores for feelings toward the modes. Using this procedure four segments were identified. These segments represented different reactions to the available modes; one was open-minded (i.e. positive about all modes), one was anti-walk (i.e. negative about walk, neutral about other modes), one was anti-car (i.e. negative about car, positive about other modes), and one was anti-bus (i.e. negative about bus, positive about other modes). Furthermore these segments represented different types of people (e.g. anti-car tended to be male university students with relatively low income etc.). However, this basis for segmentation was not significant in terms of improving the prediction and explanation of mode choice, therefore the models for these subgroups are not reported here.

In summary, the segmentation analysis demonstrates that a significantly better explanation of consumer travel behavior may be obtained by breaking the population down into distinct subgroups. This increased understanding can be helpful in guiding strategy development.

Discussion and Plans for Future Research

In general, the research results support our model of consumer transportation behavior. However, a more stringent test of the model requires the manipulation of model variables and observation of their effects. This test is necessary not only from a theoretical perspective (i.e. to test the causality of hypothesized relationships between variables), but also from a practical perspective. The model is only of value to transportation managers and planners if it can help them generate and select effective strategies for influencing consumer mode choice. Therefore, in this section, the research results will be used to generate strategies for altering consumers' mode choice and future research to evaluate these strategies will be outlined.

In accord with our model, five basic types of strategies for influencing mode choice may be generated. These strategies, each focusing on a different model variable, are summarized below.

(1) Modification of System Characteristics. Strategies designed to modify system characteristics (i.e. product strategies) are appropriate when the system does not meet consumers' needs on some dimension and this dimension is significantly related to perceptions which influence preference and choice. System strategies may range from reducing bus fares or increasing bus frequency to introducing a new paratransit mode.

(2) Modification of Consumer Perceptions. Strategies designed to modify consumer perceptions directly (i.e. not by modifying system characteristics) are appropriate when consumers are either uninformed or misinformed about the system. Here the task is to provide consumers with accurate information. In addition, modification of consumer perceptions may also be appropriate when consumers have accurate information about the system but interpret that information negatively (e.g. they know that the bus runs every half hour and interpret that as poor service). When this occurs persuasion may be employed in an effort to alter the individuals' interpretation of the information.

(3) Modification of Consumer Preference. Strategies designed to modify consumer preference may be employed when consumers' perceptions are accurate but low importance is placed on perceptions of public transportation which are positive and high importance is placed on those which are negative. In this situation the task is one of changing the importance weights so that dimensions on which public transportation performs well receive greater emphasis. Persuasive appeals may be used to do this.

(4) Modification of Situational Constraints. Strategies designed to modify situational constraints are appropriate when these factors have a significant impact on mode choice (i.e. auto availability, parking availability etc. may influence mode choice). This approach entails manipulation of situational factors so that incentives or disincentives for particular mode choices result (e.g. restricting parking in downtown areas may discourage car trips). These strategies tend to be perceived as more coercive than other types of strategies and they are often difficult to implement since legislation and regulation changes may be required. Thus, constraint modification strategies are typically only used when other strategies have failed.

(5) Modification of Behavior. Strategies designed to modify individuals' choice behavior directly are appropriate when consumers are reluctant to try a particular service but there is reason to believe that if they tried it they would like it. Promotional strategies such as free rides, discount coupons etc. may be used to encourage trial.

Now, let us use the research findings to determine what strategies are likely to increase public transit ridership in the Evanston community. First, we will examine strategies for the entire community. Then, we will discuss strategies tailored to the behavior of subgroups in the community.

The research results indicate that perceptions of general service provided by alternative modes are the most important determinant of preference and choice for the community as a whole. Thus, one strategy for increasing public transportation ridership is to improve the perceptions of the general service public transportation provides. To do this we must first examine the specific attributes which make up the general service dimension (Table 2). Attributes loading heavily on the general service factor are "on time" "correct temperature" "errands take little time", "little effort involved", "get to destination quickly", "no problems in bad weather", "easy to carry packages", "safe at night", "easy to travel with small children", and "not tiring". Of these attributes bus scores very poorly on the six that are underlined. Next, we must attempt to determine whether the low evaluation of bus on these dimensions is the result of poor system performance or a misperception of system performance by consumers.

Evidence from a separate study in which system performance was monitored indicates that, in general, the system runs on schedule (see Bernstein, Knall and Lindauer, 1977). Therefore it appears that the low "on time" rating for bus is not the result of poor system performance but rather it stems from consumers' misperceptions or lack of information regarding the system. This in-

terpretation is also supported by the finding that consumers generally could not correctly answer questions regarding the bus schedule. As a result, one strategy for improving bus general service would be to inform consumers about the good "on time" performance of the bus and educate them about the bus schedule.

In contrast, evidence from the same study of system performance suggests that consumers accurately perceive the bus travel time from their homes to downtown Evanston. Thus, the negative evaluation of bus on quickness related attributes is not due to a misperception but instead is the result of a negative interpretation of an accurate perception. Two alternative strategies for improving the "quickness" evaluation of bus and thereby improving the general service rating are appropriate: (1) modify the service (e.g., implement express buses) and (2) use persuasive communications to convince consumers that they should reinterpret the actual quickness more favorably.

Similarly, examination of the bus system performance indicates that consumers' negative perceptions of the ease of carrying packages and traveling with children on the bus are probably well founded. Perceptions of ease of carrying packages could be made more positive by altering the service to include special package racks, etc. Strategies which would increase the ease of traveling with children on the bus are not readily apparent.

Finally, consumers' poor rating of bus safety at night has some basis in reality (i.e. rapes and muggings have occurred in the past), however consumers may be overreacting to one or two isolated incidents that have been highly publicized. A two-pronged approach to improving evaluations to bus safety may be appropriate: (1) change bus system to improve safety (e.g. add guards, improve lighting etc.) and (2) inform public that actual crime rate is quite low.

The above strategies for increasing public transit ridership are all based on improving consumers' evaluation of bus on the general service dimension. An alternative approach would be to use persuasive communications to increase the relative importance of the psychological comfort dimension where bus already out performs car and walk. This might entail stressing the importance of getting to one's destination without being hassled (e.g. Greyhound's "leave the driving to us"). Or, emphasis could be placed on improving consumers' feelings about the bus and the importance of these feelings. The bus feeling factor is a function of liking for the bus, believing one ought to ride the bus, and believing significant others (e.g. family, friends) would approve of one riding the bus. Thus, strategies might focus on making the bus ride more pleasant (e.g. attractive colors, music, etc.), emphasizing one's obligation to ride the bus to conserve energy, reduce environmental pollution and please one's friends, family, coworkers, etc. Finally, once changes in the bus system have been made and it appears that the service is one that meets the needs of the consumer, strategies to alter behavior (i.e. encourage trial), such as coupons, free rides, etc. may be appropriate to help alter consumer perceptions.

The same procedure used to develop strategies for the community as a whole can be used to develop strategies for subgroups in the population. Table 7 indicates that individuals who have low auto availability place less emphasis on general service, where bus performs poorly, and more emphasis on feelings about the bus than those with high auto availability. This suggests that situational constraints which reduce auto availability will have a positive impact on bus ridership. In addition, the data provide guidelines for the development of specific strategies to reach each of these segments (i.e. focus on general service strategies for those with high auto availability and use strategies designed to improve bus feelings and general service strategies for those with low auto availability).

The choice models for the age segments also suggest using different strategies to increase public transportation ridership within age group. Members of the youth segment are strongly influenced by their feelings about the car, which tend to be negative. Thus, strategies to increase public transit ridership among the young could make their negative feelings about car salient and present bus as a more attractive alternative. The middle-aged segment is heavily influenced by perceptions of general service, therefore the strategies for improving general service discussed earlier are appropriate for increasing public transit ridership among this group In contrast, the elderly's mode choice is largely influenced by their feelings about the bus, thus strategies for enhancing bus feelings discussed earlier are particularly appropriate for this segment. Furthermore general service and convenience/accessibility are of equal importance for the elderly and young, therefore strategies effecting either of these dimensions are likely to have a similar impact.

We have illustrated how the model can be used to generate strategies for influencing mode choice. The next step in our research program will be an evaluation of these strategies. This evaluation will entail comparing the estimated costs of implementing each strategy (i.e. materials/equipment personnel time etc.) with its estimated benefits (i.e. predicted impact on ridership, subsidies, etc.). (An on-line computer package is currently being developed for this purpose). In addition, strategies will be evaluated in terms of their feasibility (i.e. whether there are any legal constraints which would affect their implementation such as labor union regulations). On the basis of this evaluation a set of strategies will be implemented and their effects will be monitored to test the accuracy of our model of consumer behavior. For example, the model predicts that changes in general service will have the greatest impact on middle aged individuals and will have less impact on the young and the elderly. Furthermore, the model predicts that strategies to reduce travel time will have a greater impact on perceptions of general service than ones which increase availability (i.e. extend hours of operation). Implementation of two strategies, one which reduces travel time and one which extends the hour of service and monitoring the impact of these strategies through direct measurement of demand (i.e. ridership counts, fare box revenues etc.), and responses to consumer surveys (i.e. surveys measuring consumers' awareness, perceptions, preference and choice in response to these changes) would allow testing these model based predictions.

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