Psychological Aspects of Mode Choice

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PSYCHOLOGICAL ASPECTS OF MODE CHOICE

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16. ABSTRACT

The primary objective of this report is to introduce psychological factors into the understanding and modeling of the mode choice process. Substantial evidence shows that traditional models of mode choice, which emphasize time and costs and a rational decision-making process, are inadequate representations of how people make transportation choices. Still, they are the primary methods practitioners use for transportation planning. The challenge is to develop models that can adequately represent qualitative factors and that also can be used for policy analysis and forecasting.

Three approaches to modeling mode choice were identified in this study: (1) rational, economic models - traditional models that employ measurements of actual time and cost and assume that people are utility maximizers; (2) models employing attitudinal and perceptual variables - the application of psychological theories and psychometric techniques to quantify factors that are basically qualitative; and (3) activity-based travel analysis - these start with the assumption that transportation choices are merely a means to engage in activities and take into account spatial, household, and other constraints.

Each approach has its advantages and disadvantages. A successful method for modeling and understanding mode choice will borrow from each of these approaches.

The report discusses several important issues in extending our understanding of the mode choice process. Those discussions can be condensed into five main themes: (1) perceptions of time and cost are more important than actual time and cost; (2) qualitative variables are important, but they are interrelated and affect perceptions of time and cost; (3) demographic variables are relatively unimportant except as they relate to mode accessibility; (4) values, beliefs and psychological needs enter into the mode choice process; and (5) the formation and breaking of habit is the key to understanding the cognitive processes involved in transportation choices.

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SUMMARY AND RECOMMENDATIONS

The primary objective of this report is to introduce psychological factors into the understanding and modeling of the mode choice process. Substantial evidence shows that traditional models of mode choice, which emphasize time and costs and a rational decision-making process, are inadequate representations of how people make transportation choices. Still, they are the primary methods practitioners use in transportation planning. It is clear, from the research evidence, that forecasters must consider qualitative factors to understand the process and to be able to produce reasonable forecasts of mode choice. The challenge is to develop models that can adequately represent these qualitative factors and that also can be used for policy analysis and forecasting.

Three approaches to modeling mode choice were identified in this study:

1. rational, economic models -- traditional models that employ measurements of actual time and cost and assume that people are utility maximizers;

2. models employing attitudinal and perceptual variables -- the application of psychological theories and psychometric techniques to quantify factors that are basically qualitative; and

3. activity-based travel analysis -- these start with the assumption that transportation choices are merely a means to engage in activities and take into account spatial, household, and other constraints.

Each approach has its advantages and disadvantages. A successful method for modeling and understanding mode choice will borrow from each of these approaches.

The body of the report discusses several important issues in extending our understanding of the mode choice process. Those discussions can be condensed into five main themes:

1. perceptions of time and cost are more important than actual time and cost;

2. qualitative variables are important, but they are interrelated and affect perceptions of time and cost;

3. demographic variables are relatively unimportant except as they relate to mode accessibility;

4. values, beliefs and psychological needs enter into the mode choice process; and

5. the formation and breaking of habit is the key to understanding the cognitive processes involved in transportation choices.

Below is a summary of these themes and recommendations following from them.

PERCEPTIONS OF TIME AND COST

The idea that people make transportation decisions on the basis of their perceptions of mode attributes rather than their actual values seems self-evident. Several research studies have supported this proposition. Time appears to be more important than cost in mode choice; however, both are important. The perception of time is influenced by several factors. Time cannot be simply separated into categories such as in-vehicle and out-of-vehicle time. Reliability may be more important than time. Many individual factors influence the perception of time as well as its value. The same can be said for cost factors. We cannot assume that people fully account for all costs in their decision-making process. Therefore, people's perceptions of time and costs must be measured.

> Recommendation 1: Mode choice research should include measurements of perceived time and cost as well as actual time an cost. It should also include measurement of perceived variation in time. In order to understand people's decision process, perceptions of all modes should be measured, whether they were chosen or not.

QUALITATIVE VARIABLES

Research on the importance of qualitative variables such as convenience, comfort, reliability, safety, and privacy has had mixed results. The evidence that these variables are important in mode choice is sufficient, but clarity in the relationships among these variables and mode choice is hampered by the fact that the variables are all interrelated. No standard ways to measure the variables have

emerged in the research, and there is often confusion among them. This does not mean, however, that they should not be considered. They are critical to understanding mode choice.

> Recommendation 2: Mode choice research should incorporate measurements of people's attitudes toward specific factors that make up these qualitative variables. Psychometric scaling techniques should be used to define the dimensions that are relevant to individual mode choice.

DEMOGRAPHIC VARIABLES

Information on demographic variables is generally collected in mode choice research. The information has been used directly in logit and regression models. It has also been used to segment respondents to develop separate models. It has been used to modify other measurements (e.g., dividing cost by income to determine relative cost). However, whenever mode accessibility has been included in a model, it has turned out to be the critical factor in mode choice. Income, gender, education, race, and social class are highly interrelated. In addition, they are correlated with auto ownership, size of family, and number of workers -- all factors that help determine people's access to automobiles. Auto accessibility is a primary determinant of mode choice. Demographic variables have little effect on mode choice independent of this factor.

Recommendation 3: Mode choice research should always include direct measurement of auto and bus accessibility. This means direct measurement of the number of automobiles, the number of workers, and the number of licensed drivers in a household, as well as household decision-making processes for allocating use of the car. Often, the best way to introduce demographic information is in a two or more stage model that predicts auto ownership independently of mode choice.

VALUES, BELIEFS, AND PSYCHOLOGICAL NEEDS

The evidence is ample that people's transportation choices are affected by individual characteristics that are not necessarily related to demographic variables. These individual differences in values, personality, ways of dealing with stress, and satisfying psychological needs account for individual variation in mode choice when the objective choice environment is the same. However, the body of research relating this area to transportation decisions is small, and the relationships are not well-understood. Most mode choice research projects cannot afford to delve deeply into developing an understanding of these factors because of the resources required.

Recommendation 4: More research should be done on the influence of non-demographic differences such as values, personality, and satisfying psychological needs on mode choice. Because of the difficulty of including such variables in planning-oriented mode choice research, doing so may not always be appropriate. However, it is important to recognize that these factors do play a part in the process and can often be used to interpret perplexing results.

HABITS

The cognitive processes discussed in the body of this report all serve to reinforce habitual behavior. Once a choice has been made, people have a tendency to reinforce that choice by changing attitudes and perceptions so that their beliefs support their choice. They also tend to emphasize the importance of the attributes that support their choice. As a result, the processes they use to combine evaluations

of attributes tend to stop short with those that are consistent with the choice they have made. In addition, they are not likely to seek out knowledge that would tend to change their choice.

> Recommendation 5: The influence of habit should be explicitly recognized in mode choice models. This can be done by acknowledging the influence of choice on perceptions, recognizing the lag in mode shift, accounting for different types of knowledge-seeking behavior, and avoiding additive multi-attribute models. Accounting for habit and its underlying cognitive processes implies doing longitudinal rather than cross-sectional studies.

IMPLICATIONS

Each of these themes has implications for designing and promoting alternative transportation systems as well. Since perceptions of time and cost are so variable and so important in mode choice, the opportunities to affect those perceptions should be taken advantage of. Qualitative factors in mode choice such as convenience, comfort, reliability, safety, and privacy are all important and interrelated. None can be ignored. Auto ownership is critical to mode choice. Promotions of alternative modes would do well to emphasize the advantages of not owning an extra automobile rather than of not using it. Subtle psychological needs and differences do enter into transportation decisions. It is important not to assume that people will always respond to rational arguments for mode shifts. Understanding the influence of habit is important in promoting alternative transportation modes. The critical time to persuade people to shift modes is when they experience life changes such as moving, changing jobs, or having children.

In general, it is important to recognize that people are not rational, economic decision-makers. Mode choice models should account for this. Alternative transportation systems should be designed to respond to the whole range of factors that influence decisions. Promotions for alternative systems should also appeal to that whole range.

INTRODUCTION

In traditional methods for planning transportation systems and forecasting the use of those systems, transportation planners rely heavily on travel time and cost factors to explain how people choose transportation modes. Certainly, these factors are important, but they do not explain everything about people's behavior. We know that some people carpool or use the bus, even when the use of these modes is contrary to the people's economic benefit. We also know that some people will always drive their cars alone to work, no matter what economic incentives to do otherwise are presented to them.

Even though people are aware that the traditional mode choice modeling process is deficient, and even though a great deal of research has gone into improving the process in the last 15 to 20 years, practicing transportation planners still, by and large, use the traditional approaches. The situation was summed up well by Michaels (1980):

> . . . the planning process reduces to a straightforward (albeit complex) mechanical operation in which manifest behavior is relevant . . . the field of planning has used a series of very simple behavioral assumptions to create a process for making long-term transport investment decisions. It is a process that has never worked very well; it predicts poorly and the models are not generalizable. This does not surprise any behavioral scientist who has studied planning models. The assumptions are behaviorally naive. The fact that the models work as well as they do is a measure of how constrained work-trip travel has been and of the perseverance of planners in manipulating the models. (pp. 3-4)

Michaels' main point is that when we do not understand the process, we cannot expect to make good predictions nor to evaluate the impacts of policy decisions. Even more recently, Koppelman (1988) supports this contention.

> The value of increased understanding of travel behavior has been downplayed by some. I submit that it is only though increased understanding that we are likely to improve the quality of our ability to represent and forecast travel behavior and thereby to properly support policy analysis and decision making. (p. 58)

The primary objective of this study was to investigate all possible avenues that could increase our understanding of the mode choice process. To do this, over 200 reports on mode choice published in the last 20 years were reviewed. The studies came from a wide variety of sources, including traditional transportation journals and journals of psychology, geography, psychiatry, anthropology, economics, market research, and others. An annotated bibliography of this literature review is available under a separate cover. In addition, some analysis of local data sources was used to corroborate findings from studies in other areas.

One of the main themes that came out of this literature review is that some of the most important aspects of the mode choice process are also the most difficult to measure. This does not mean that we should ignore factors that are difficult to measure or to forecast. Hartgen and Wachs (1974) recommended that the

> . . . analyst should resist the temptation to opt for a model based only on easily measured performance variables when it is apparent that significant qualitative factors also influence the choice process. (p. 122)

Attitudes and other psychological factors have been the subject of a great deal of research. The fact that transportation **behavior** is relatively easy to measure should encourage us to apply psychological theories concerning the relationship between attitudes and behavior to this practical field.

An abundance of evidence indicates that travel time and economic factors alone cannot explain transportation decisions. For instance, Reser (1980) pointed out that the automobile's popularity cannot be explained on rational bases alone:

> The seeming insensitivity to costs and inconvenience would suggest that the private car is serving other than utilitarian needs . . . convenient transportation, perceived freedom and autonomy, sexual and aggressive symbolic expression, status and identification value, and familiarity and security . . . and individual control over the environment. (p. 281)

One of the challenges facing anyone interested in understanding the mode choice process is how to measure and account for the qualitative variables that enter the process.

A second challenge is how to use an increased understanding of the mode choice process to analyze policy and to make better forecasts. Some argue that even though attitudinal and other qualitative factors are important to the choice process, our inability to forecast them makes them useless in predicting future mode choice. However, people who make that assertion also find considerable disagreement. For instance, Levin and Louviere (1981) argue that ". . . the application of psychological process theories has the potential of providing **better** forecasting tools and **increased** policy sensitivity." (p. 48, emphasis mine) It is debatable whether we can predict changes in quantitative variables such as travel time and cost better than we can some of the qualitative variables that are the focus of this study. Certainly we can not consider qualitative variables if they are not part of the models.

Methods have been developed that have the potential to improve transportation models. Hartgen (1981) points out that

> . . . recent improvements in methods have flowed from two major streams of thought . . . The first encompasses mathematical modeling using data at the level of the individual trip-maker [and borrows from] economics, psychology, mathematics, and statistics, and as a group, they are highly advanced and perhaps 10 years ahead of transportation planning practice. The second approach . . . emphasizes the social and psychological aspects of travel behavior. (p.6)

All of these methodological improvements center on the measurement and incorporation of individual attitudes into mode choice models. The interpretations and use of attitudes vary widely, but most of these approaches have in common the assumption that attitudes mediate the connection between the attributes of transportation modes and the behavior of people with respect to those modes.

Levin (1979) provides an interesting interpretation of attitudes. He says that ". . . attitude measurement is intended to replace knowledge of an individual's past

history and represents an attempt to assess probable future behavior." (p. 758) In other words, the use of attitudes may be seen as an efficient and more accurate way of using historical data than the accumulation and analysis of the previous behavior related to mode choices. This report focuses on the use of attitudes and the associated cognitive processes in the improvement of our understanding of transportation mode choice.

The remainder of this report is organized into two sections. The next section describes three major types of approaches to mode choice modeling, along with their strengths and weaknesses. The remainder of the report covers issue areas that have been uncovered in the past 20 years of research and includes implications for designing, promoting, and developing policies for various transportation modes.

TYPES OF APPROACHES

The techniques used to analyze mode choice are many and varied. It is difficult to clearly delineate independent approaches. The methods overlap a great deal. Each method has its strengths and weaknesses and each one has different applications. In this study, it was useful to identify three classes of mode choice models:

1. rational, economic models,
2. attitude-based models, and
3. activity-based models.

In this section, the origins and characteristics of each of these types of models will be described.

RATIONAL, ECONOMIC MODELS

These models are based on economic theory. They assume that people are utility maximizers. In other words, they assume that people evaluate the attributes of all their choices, assign some utility to each attribute, add up the utilities, and choose the option that has the highest utility. The challenge in developing such models is to find the appropriate weights to assign to each attribute. Trade-offs among attributes can then be analyzed. For instance, an analyst may determine that a 10 cent increase in bus fare is equivalent to a decrease in travel time of 5 minutes. Using such information, policy changes can be evaluated and forecasts can be prepared on the basis of different scenarios.

The attraction of utility-based models is that they are easily quantified and have attractive mathematical properties. However, the models have been criticized for not having a sufficient behavioral foundation (e.g., Hartgen and Wachs, 1974, and Bullen and Boekenkroeger, 1979). The cognitive processes involved in decision-making are more complex than represented in traditional utility-based

models. Even though they may be able to reproduce much of the behavior observed in actual mode choices, the fact that they are not in direct correspondence to actual cognitive processes means that they do not help our understanding of the phenomenon and may not be useful in predicting reactions to new situations.

Utility-based models tend to emphasize travel time and cost factors. Some researchers, such as Nicolaidis (1975) and Stopher (1977), have urged the inclusion of qualitative variables such as comfort and convenience in utility-based models. Spear (1976) demonstrated a significant improvement in predictability when a variable representing convenience was added to information about the time and cost of competing modes. Factors such as comfort and convenience can be measured objectively. However, individual perception is especially important when the impact of these factors on mode choice is assessed.

In the same vein, utility-based models tend to emphasize objective or "engineering" values for the factors that go into the models. For instance, travel times are usually calculated using the origins and destinations of the trips and the average travel speeds between them. Perceived values for time and cost could be used in utility-based models. In fact, Dobson and Tischer (1977, 1978), among others, showed that perceived values worked better than objective values in explaining mode choices. However, measuring perceived choices requires additional data collection. In addition, using perceived values in forecasting mode choice requires making predictions of perceptions.

One of the criticisms of utility-based models is that they are not generalizable from one geographic area to another (e.g., Watson and Westin, 1975). Several researchers have attempted to improve transferability by segmenting the population according to socio-demographic factors and developing separate models for each segment. This should lead to models that could be applied to different geographic areas that have similar socio-demographic characteristics. However, this approach has met with mixed success. Ben-Akiva and Richards (1976) found that the only

socio-economic variable that improved predictions was vehicle availability. Recker and Golob (1976) found that segmentation according to perceived access to different transit modes led to the most successful analysis of mode choice. Nicolaidis, Wachs and Golob (1977) tested six ways of segmenting populations and found that segmentation according to demographic criteria is the best way to test satisfaction with service improvements in an analysis of the choice between bus and car.

Another important issue in the use of utility-based models is the degree of aggregation employed. The traditional practice in transportation modeling is to predict mode choice of aggregations of people from aggregate characteristics. The problems of geographic generalizability have already been discussed. There are other problems with this approach as well. Stopher and Lisco (1970) and McGillivray (1972) enumerated several problems with aggregate models. Some problems are statistical and involve the size and character of the variability of characteristics in any group of people defined by a geographic area. The primary problem, however, is that the assumption that aggregate relationships represent individual behavior is a fallacy. This problem has been labeled the "ecological fallacy."

For the last 20 years, the vogue (in utility-based models) has been the development of "disaggregate behavioral models." These models are calibrated at the level of the individual. Thus, they avoid the "ecological fallacy." In addition, they are flexible, since they can be aggregated at any level. However, even these models have been strongly criticized. For instance, Bullen and Boekenkroeger (1979) maintain that these models still do not represent the actual cognitive processes involved in decision-making and that they do not deal with household level decisions. They say that market segmentation is simply an ad hoc response to deficiencies in the ability of the models to handle demographic variables. Hartgen and Wachs (1974) maintain that these models are disaggregate only in the sense that

individual observations are used in the model calibration. In forecasting, the results are aggregated. In addition, aggregation of information occurs. Data are coded into finite levels, travel times are based on zone centroids, trip segments are aggregated into in- and out-of-vehicle time, and other types of aggregation occur.

The criticisms of traditional mode choice models, even disaggregate ones, have led to the development of two other approaches to the question: attitude-based models and activity-based models. These are covered in the next two sections.

ATTITUDE-BASED MODELS

These models have their basis in psychology and market research. Two types of influences from psychology have been blended to guide much of the market research on mode choice: decision theory and psychometric analysis. Psychological decision theory with a cognitive basis has attempted to describe the actual processes that people use to make decisions. Most of these theories use a construct such as "attitude" to describe how people perceive and process the attributes of alternatives and make a choice. Utility-based theory does not employ such a construct. The second influence of psychology on market research models, psychometric analysis, is a set of techniques for deriving "attitudes" from quantitative measurement tools such as questionnaires, surveys, and behavioral indicators. No single technique is appropriate for every set of data, and the type of data collected depends to a great extent on the questions being answered. This section contains a brief introduction to these two influences of psychology on mode choice studies.

Cognitive Decision-Making Models

There are generally several stages in cognitive decision-making models. For instance, in an excellent paper by Tybout and Hauser (1981), the authors propose an "integrated model of consumer choice" that employs three stages, as illustrated in Figure 1. "Physical characteristics," or actual attributes of the alternatives, lead to

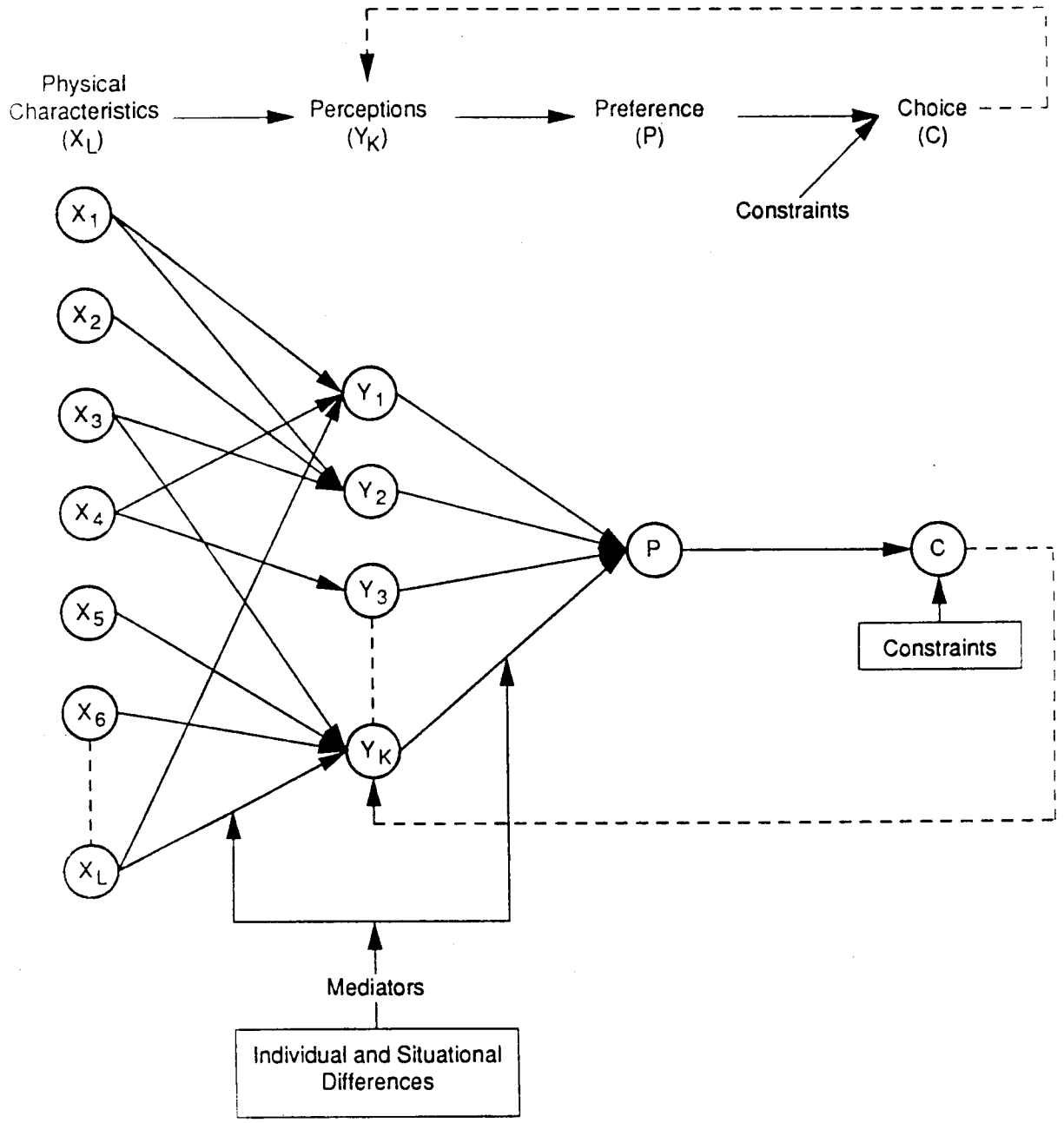

Figure 1. An Integrated Model of Consumer Choice

perceptions (here the authors use "perception" in the same way that other researchers use the term "attitude"). Individual and situational differences are posited to affect the way people combine knowledge of physical attributes into perceptions.

In the second stage of the model, perceptions are combined to lead to a preference. Again, individual and situational factors affect how this process works. The individual preference does not necessarily determine the choice. At the third stage of the process, the actual choice is influenced by constraints, such as car availability, weather, or other household members' travel needs. Another part of the model is the feedback loop, shown as a dotted line. This important aspect describes the influence of experience on perceptions of the alternatives.

These authors refer to the efforts of several psychologists working in the area of decision theory, including Brunswik (1952), Fishbein (1967, 1972), Rosenberg (1956), Norman (1976), and Bem (1972) in the development of their model. The fact that the model is "integrated" is very important. As Tybout and Hauser say,

> . . . models that consider consumer choice to be a function either of physical characteristics or perceptions, or a combination of the two, have limitations for a marketing audit. Models that base choice solely on physical characteristics may exclude consideration of communication strategies as a means of influencing choice by modifying perceptions directly. Models that view choice solely as a function of perceptions provide little guidance as to which physical product characteristics should be emphasized in communications or considered for follow-up research on product design. Models that simultaneously employ both physical characteristics and perceptions of choice are subject to problems of interpretations. (p. 84)

In addition, models that ignore the feedback loop do not provide guidance for dealing with people's past experience with mode choice.

Koppelman and Lyon (1981) tested the importance of "perceptions and feelings" in an analysis of work and school travel by using a model similar to Tybout and Hauser's. They found that measurements of attitudes added significantly to the

understanding of preference and choice when they were included with information on objective characteristics of the modes.

Other investigators with a market research orientation have adopted similar approaches to representing the mode choice process. Their elaboration of the process that connects the physical characteristics with the choice is driven by the desire to understand how people make the choices and to be able to intervene in the process. If the aim were simply forecasting mode choice, the intervening processes would seem less important. However, as discussed above, there are advantages in forecasting to better understanding the process.

Psychometric Analysis

The measurement and quantification of perceptions and preferences in a market research model are essential. A great deal of literature exists describing different approaches to accomplish this task. Details of the statistical intricacies of each approach are beyond the scope of this report. However, to introduce the reader to some of the issues, a brief discussion of some of the alternatives is presented here.

One of the questions in assessing perceptions is how to measure the importance of a particular attribute of different modes, for instance, comfort. Comfort is a multidimensional variable. In other words, several characteristics of a mode influence people's perception of "comfort." For instance, work by Nicolaidis (1975) identified two major contributors to people's perception of comfort, physical exertion and control of the environment. Within each of these contributors, several mode characteristics combine to determine a person's perception of "physical exertion" or "control of the environment."

Psychological measurement techniques, or psychometrics, are used to quantify these perceptions. Numerous approaches exist to combine multiple measurements into scales that are useful for conceptualizing and quantifying perceptions. Factor analysis, cluster analysis, and multidimensional scaling are all

examples of techniques used to define these combinations. The basic aim of these techniques is to find underlying dimensions from measurements of people's responses to individual questions.

Specific measurement tools have been under development for decades. Category scaling techniques such as semantic differential scaling and Likert scaling are examples of direct approaches to such measurement. These are the familiar five- or seven-point scales that are used to measure preference, liking, agreement, or other perceptual responses to characteristics or modes. The paired comparisons method presents alternatives two at a time. From a set of responses to these pairs, an ordinal ranking of alternatives can be determined. In recent years, "conjoint measurement" has been in vogue. In this method, alternative choices containing multiple characteristics are presented to the respondent. For instance, someone may be asked to choose between a trip that takes 45 minutes, costs 50 cents, and requires 10 minutes of walking and a trip that takes 30 minutes, costs $2.00, and involves no walking. By asking a person's preference among a number of combinations like this, the relative importance of total time, trip cost, and walking time can be quantitatively assessed.

Psychology has contributed to mode choice modeling by introducing a more behaviorally based model of human decision-making than utility models. It has also contributed a wide variety of statistical techniques to measure the different components of the model. Its weakness has tended to be in paying enough attention to the practical aspects of travel decision-making. That is where activity-based models have made the most important contribution.

ACTIVITY-BASED MODELS

The basis for activity-based travel analysis is the idea that travel behavior is derived from the pattern and structure of activities rather than as an end in itself. The emphasis is therefore on the importance of time and space constraints in

performing activities. Additionally, it tends to consider the constraints of household decision-making, the chaining of multiple trips, and the influence of habit and patterns of travel. Pas, as quoted in Kitamura's (1988) excellent evaluation of activity-based travel analysis, summarized the areas of investigation as follows:

- demand for activity participation;
- activity scheduling in time and space;
- spatio-temporal, interpersonal, and other constraints;
- interaction in travel decisions over time;
- interaction among individual; and
- household structure and roles. (p. 11)

Because of the emphasis on human activities in general, travel is not considered an entity on its own. Thus, the practical aspects of travel choices receive the attention they deserve.

One criticism of activity-based travel analysis is that it is fragmented and does not contain a cohesive theory of travel decision-making. Those engaging in this kind of analysis tend to be the most critical of the field. They lament the fact that activity-based travel analysis has not been used much in practice. According to Kitamura (1988), only once has a formal activity-based model been applied to actual policy analysis. The lack of application may be a result of the newness of activity-based travel analysis. The early origins of the work are in the early 1970s. The field has developed during a time when funding for research has diminished (Kostyniuk, 1988). Even if no cohesive theoretical framework has resulted from activity-based travel analysis, its concepts have influenced much of the research going on today. For instance, Hanson (1988) points out that the data necessary for her research (women's labor markets) were not even available 15 to 20 years ago and may not have been available today, were it not for the influence of activity-based travel analysis.

Kitamura (1988) describes five areas of current development in activity-based travel analysis:

- influence of household lifecycle, including the presence of children, as one of the most important determinants of activities and travel patterns;
- time constraints on activity and travel behavior, such as typical store hours and work schedules;
- daily travel patterns, which are in response to daily patterns of activities;
- multi-day travel patterns; and
- dynamic aspects of travel behavior, especially the influence of habit formation and persistence.

Each of these areas of research have influenced how data are collected and what types of information are investigated in market research studies and other current studies of travel behavior. An emerging area of research influenced by activity-based travel analysis concerns the substitution of in-home activities for out-of-home activities. Telecommuting, the emergence of delivery services, and home entertainment choices are examples of these phenomena.

SUMMARY

The three approaches to mode choice modeling are not mutually exclusive. Economic models have incorporated "soft" variables that have been explored through market research approaches. On the other hand, attitude-based models employ utility-based models for stages in the representation of cognitive process. Activity-based travel analysis has influenced both of the other types of approach to mode choice modeling. The "ideal" mode choice model would incorporate elements of each of these archetypical approaches to understanding travel decision-making.

ISSUES IN MODE CHOICE

In addition to developing theoretical approaches to the study of mode choice, researchers have developed a great deal of information concerning the impact of specific aspects of the choice on the ultimate outcome. The understanding of these issues can be helpful in the design and evaluation of transportation programs and in the promotion of different transportation modes. For purposes of clarity, this section is divided into four parts. The first deals with characteristics of the modes themselves that influence decisions. The second covers individual and household characteristics that are related to mode choice. The third section defines some of the psychological motivations that underlie transportation decisions. The fourth analyzes the influence of cognitive processes on mode choices.

MODE CHARACTERISTICS

Traditional mode choice models assume that decisions are based on a comparison of the attributes of modes, modified to some extent by the individual decision-maker's background and experiences. Mode attributes are obviously an important element in understanding the process. Seven major attributes are discussed here:

- time,
- cost,
- convenience,
- comfort,
- reliability,
- safety, and
- privacy.

Research studies of mode choice typically include many more than seven attributes that are important in the decision. However, these seven **general** characteristics encompass almost all attributes that have been considered in other studies.

Time

It may seem unusual to begin the discussion of psychological issues affecting mode choice with an attribute that is one of the most traditional elements of transportation models, whether psychologically oriented or not. However, the time necessary to make a trip is unquestionably one of the most important determinants of choice. What the psychological literature has to add to our understanding of the influence of travel time is an interpretation of the **meaning** of time to the individual.

Importance of Travel Time. The evidence that travel time is the most important aspect in mode choice is generally supported by research. In an early review of mode choice models, McGillivray (1970) found that travel time is always more important than travel cost in affecting mode choice. Paine, Nash, Hille, and Brunner (1969) found that the largest difference in satisfaction between auto and bus was related to travel time. Horowitz and Sheth (1977) found that time loss was the most important deterrent to people's choice of carpooling as a travel mode. Logit models invariably find that travel time is a significant variable in predicting mode choice (e.g., Talvitie and Kirshner, 1978). Not surprisingly, in our fast-paced culture, people place a high value on time. Yago (1983), in his review of the sociology of transportation, points out the detrimental effects of long travel times on social interaction, resulting primarily in less time with the family. Travel time will always be critical in our travel decisions.

Some findings have contradicted this widely accepted understanding of the high value of travel time. Fenwick, Heeler, and Simmie (1983) conducted a study of the means to switch auto drivers to transit. They found that time was less important than cost, convenience, and comfort. Srinivasan, Flachsbart, Dajani, and Hartley (1982) evaluated the importance of mode attributes for current auto users. The

auto users were divided into those who were prone to transit, those who were prone to carpooling, and those who would be very unlikely to shift. They found that time was relatively less important than cost for the carpool-prone group, but that it was most important for the transit-prone group.

Perception of Travel Time. Perhaps some of the conflicting evidence on the effects of travel time is due to different ways of interpreting it. There can be a large difference between perceived travel time and actual travel time. Spear (1976) discovered that perceived time better predicted mode choice than did actual time. Dobson and Tischer (1977) compared three different models for mode choice, using (1) actual times and costs, (2) perceived times and costs, and (3) demographic variables. The second model performed better than either of the other two or a combination of the other two. In fact, when the first two models were combined, actual travel time was not a statistically significant contributor to the combined model. Many researchers, including Golob and Dotson (1974); Gilbert and Foerster (1976); Meyer, Levin, and Louviere (1978); and Tybout and Hauser (1981), have urged the use of perceived time values rather than measured values in modeling mode choice.

In a comprehensive review of studies concerning the value of time, Bates, Roberts, Gwilliam, and Goodwin (1987) hypothesized several factors that can influence how people perceive time. The factors include the following:

1. availability of time and money,
2. personal and household characteristics,
3. scope of activities to be undertaken,
4. degree of comfort,
5. alternative uses to which it could be put,
6. predictability or reliability,
7. amount of time saved, and
8. duration of journey.

Prahsker (1979) supported the seventh hypothesis with the finding that people are less irritated with each additional amount of time, up to a point. Several of these hypotheses were corroborated in research by Henley, Levin, Louviere, and Meyer (1981). They found that the perception of travel time varied as a function of the mode, the degree of comfort, and the level of convenience.

The quest for the elusive "value of time" is more frustrating the more one researches it. Williams (1978) demonstrated that total travel time is more important for work trips than for shopping trips. He also found that walking time is seen as more onerous than waiting time, in general. However, Thomas and Thompson (1971) obtained results that contradicted Williams'. They found that time was most valuable to people during personal business trips and least valuable for work trips. Recreational and shopping trips were in between. Traditionally in logit mode, choice models account for in-vehicle and out-of-vehicle time separately. As a further confirmation of Bates', et al., third hypothesis, Talvitie and Kirshner (1978) found that it is critical to separate walking and waiting time when accounting for the effects of out-of-vehicle time. As a further fine tuning of this hypothesis, Train (1978) demonstrated that commuters did not value time spent walking to BART the same as time spent walking to the bus.

Introducing another level of complexity in the understanding of the value of travel time, Westin and Watson (1975) found that attitudes affect the importance that travelers apply to travel time. They also found that the attitudes are independent of current mode choice and the travel times that people experience. In other words, there are differences among peoples' attitudes that cannot be directly related to their travel choices, but nevertheless affect how much they value time. All of the research on the value of time and the perception of time shows that the situation determines how people perceive travel time. Relying on the clock time in travel choice models can easily produce misleading results.

Implications. The implication of the research on travel time for designing and promoting high occupancy modes is that the impact of increased actual travel time resulting from ridesharing can be mitigated to some extent. First of all, for some people, travel time is **not** the most critical factor in their travel decisions, even though it is important in general. Targeting these people is the most efficient way to change travel behavior. Second, the impact of travel time can be reduced if rides are made as comfortable as possible. This should lead to strong consideration of luxury vehicles for ridesharing. The extra costs for comfortable buses and vans may well be worth incurring. Third, long travel times can be made less onerous if convenience is increased, **even if the travel time is the same**. Good information should be provided. Amenities such as places for packages are important. Fourth, reliability is important. People are much more willing to tolerate a long trip than they are a trip of an unknown length, especially for the journey to work. In summary, time is an important factor in people's travel decisions; however, the critical factor is how they perceive the time and how much they value it. Many opportunities exist to affect that perception.

Cost

Trip cost is another important element in the mode choice decision. However, research has uncovered mixed results concerning its importance relative to other mode characteristics. Mitchelson and Gauthier (1980) found that, among nine mode characteristics, cost was second behind "physical effort." Parody (1977), in a comparison of several approaches to modeling mode choice, found that cost was a significant contributor to all of them. Srinivasan, Flachsbart, Dajani, and Hartley (1982) showed that cost was the most important factor in mode choice for auto drivers, whether they were transit-prone, carpool-prone, or committed auto users. It was especially important for carpool-prone people. However, Ben-Akiva and Richards (1976) found just the opposite. Out-of-pocket costs did not enter significantly into a prediction of mode choice in a disaggregate behavioral model.

McGillivray (1970) showed that cost was never a stronger predictor than travel time in any model he reviewed.

The importance of cost may depend on the type of trip involved. However, the evidence on this point is inconclusive. Norman (1977) found that the importance of cost was about the same for work and leisure trips. On the other hand, Williams (1978) showed that travel cost is not important for work trips, but is for shopping trips.

Disparity in Importance of Travel Costs. Why is there such a disparity in results? The answer lies partly in the way research is designed. For instance, Ayele and Byun (1984) concluded that cost factors were more important than any other factors in predicting participation in ridesharing programs. However, this conclusion is questionable, because they included a very narrow range of alternative factors in mode choice. Perhaps the best explanation is the difference between perceived and actual costs. Dobson and Tischer (1977) demonstrated that perceived costs worked better than actual costs in predicting mode choice. Golob, Horowitz, and Wachs (1979) urged that perceived and actual costs should always be included in studies of mode choice, since there is a disparity between the two and since people's choices are based on their perceptions. The exclusive use of actual travel costs can easily lead to wrong results.

Several studies have explored how people perceive the costs of their trips. For instance, Henley, Levin, Louviere, and Meyer (1981) found in one survey that

> . . . car users were generally unknowledgeable about the costs of driving a car to and from work, and they tended to *underestimate* the fixed plus operating costs of using a car in comparison to taking the bus. (p. 31)

They conducted a similar survey after large increases in gasoline price due to the energy crisis. They found that more people were able to provide estimates of costs, but that they still tended to underestimate costs relative to taking the bus. Hoag and Adams (1975) showed that people held large misperceptions of the true costs of

using autos. Fifty percent of the study group included only gas, oil, and grease; 3 percent added parking and tolls; 25 percent added depreciation and repairs; and 6 percent included licenses and insurance. None indicated that taxes or the value of time entered into their estimate of costs. Westin and Watson (1975) found that 90 percent of the people in their survey included only gas and oil in their estimate of costs.

The importance that people attach to travel cost and the satisfaction they have with cost varies according to attitudes and experience. For instance, Westin and Watson (1975) demonstrated that people can be segmented by attitudinal data to identify a subgroup to whom cost is very important. The importance of cost is not uniform across the population. Golob, Horowitz, and Wachs (1979) found that mode choice affected satisfaction with cost. Bus commuters were relatively more satisfied with cost of bus versus auto travel than were auto commuters, and vice versa.

Another possible explanation of the different results concerning the importance of cost in mode choice is that it enters in at different places in the decision (Banister, 1978). People consider some types of costs when they decide to buy a car. They consider the others when they decide to use the car. Ben-Akiva and Richards (1976), among others, demonstrated that vehicle availability was important in modeling mode choice, but that out-of-pocket costs were not. In other words, once a person or household has decided to buy a car, it has accepted the costs of depreciation, insurance, licensing, and to some extent, maintenance, which comprise the majority of the actual operating costs. The remaining out-of-pocket costs are relatively minor (with the possible exception of parking cost) and do not influence use very much.

Three international studies (Bates and Roberts, 1981; Uusitalo and Djerf, 1983; and Pucher, 1988) showed that car ownership is related to real income, while car use is related to real gasoline price and fuel economy. Surprisingly, parking

costs were not shown to be significant, probably because these studies dealt with European countries where the cost of gasoline is relatively higher than in the United States, compared with parking. The conclusions that can be drawn from all this research are that (1) auto ownership (especially with respect to number of workers or drivers in the household) is a major factor in mode choice and (2) once a car is purchased, the most important auto operating costs have already been accounted for. The remaining costs have relatively little impact on the decision to use the car.

Reinforcement Studies. A series of research projects have attempted to understand the influence of cost by experimenting with monetary reinforcements. The experiments have borrowed from the field of behavior modification. The basic hypothesis is that behavior can be changed through the application of rewards and punishments. A series of research efforts by Everett and his associates, including

- Everett, Hayward, and Meyers (1974);
- Deslauriers and Everett (1977);
- Deslauriers (1975);
- Deslauriers and Everett (1977);
- Deslauriers (1978);
- Everett, Studer and Douglas (1978);
- Everett, Deslauriers, Newsom, and Anderson (1978); and
- Everett (1981)

investigated the use of free bus passes and tokens that could be exchanged for merchandise to increase transit ridership. In general, they found that such incentives did raise ridership, at least temporarily. Furthermore, they found that occasional reinforcement worked as well as continuous reinforcement, thereby making it a more cost efficient way to increase ridership. The long term effects on bus ridership were not measured. However, one study (Deslauriers, 1978) did find that attitudes toward bus ridership improved after people were induced to ride, indicating a potential for long term changes in behavior. Katzev and Bachman

(1982) found that discounts and free rides increased bus ridership, but that it returned to normal after the reinforcement was withdrawn.

Other studies have investigated the use of reinforcements on increasing carpooling (Jacobs, Fairbanks, Poche and Bailey, 1982) and on reducing the amount of auto usage (Hake and Foxx, 1978 and Foxx and Schaeffer, 1981). In all three of those studies, the desired behavior was increased through the use of monetary reinforcements. In the carpooling experiment, the higher level of carpooling remained after the reinforcement was discontinued. However, the reinforcement had been accompanied by access to reserved parking for carpoolers, which was continued after the reinforcement had been dropped.

Implications. Research related to the impact of cost factors on mode choice has had mixed results. The primary reasons for the disparities in results is that cost means different things to different people, and perceived costs vary widely from actual costs depending on people's experiences with and attitudes toward different travel modes. In addition, the research has emphasized that cost factors enter at two different stages -- at purchase time and at usage time.

There are at least three implications of the research on cost for designing and promoting transit and ridesharing:

1. Cost issues may not be as important as people assume. Reduced costs for transit or ridesharing may be a good way to get people to try different modes, but the mode shifts may not persist unless the new mode provides other important advantages.

2. Trying to get people to consider fixed costs of the automobile when choosing modes may be fruitless. Once they have purchased an automobile, they have already accepted those extra costs, and they are not likely to consider them in their usage decisions.

3. Promotions should emphasize the decision between auto **ownership** and ridesharing, rather than auto **use** and ridesharing.

Cost is an influence on mode choice, but it is important to distinguish among the different elements of cost and to consider people's different perceptions of cost.

Convenience

Transportation researchers and other professionals have long recognized that convenience is an important factor to include in the design of transportation facilities and services. As early as 1969, Paine, Nash, Hille, and Brunner studied the importance of convenience in the choice between auto and public transport alternatives. Using a set of 33 items that described all aspects of different modes, they identified the important dimensions from this set using factor analysis. They analyzed the importance of these items for work trips and non-work trips separately. The eight dimensions, or factors, that emerged for work trips did not include convenience. However, it did turn out to be an important dimension for non-work trips.

Stopher (1977) urged the use of psychometric techniques to include subjective variables such as convenience in behavioral travel models. He enumerated three steps in the process:

1. the techniques need to be used for attribute identification, for example, determining the attractiveness of alternative destination opportunities;

2. indices may be defined from these identifications of attributes which can in turn be inserted into revealed-behavior models [which] will help to determine the importance of the indices in the individual's decision-making process; and

3. the important indices need to be correlated with physical planning parameters, possible of transportation systems or of activity opportunities. (p. 79)

He emphasized the fact that the inclusion of qualitative variables is useless for planning purposes unless they can be connected with physical or policy options that can be changed.

Convenience is one of the qualitative variables that has often been included in behavioral travel models, with some success. Mitchelson and Gauthier (1980) found that convenience is one of six important cognitive dimensions with which people perceive transportation alternatives. Spear (1976) developed a generalized

convenience variable and found that a logit model employing the variable fit the observed data significantly better than without it.

Convenience has also entered into the analysis of ridesharing modes. Blankenship and David (1976) found that convenience was the single most important reason that people switched to carpooling. The three most important components of convenience for these people were relief from driving every day, being able to use preferred parking, and being able to leave their car at home for other purposes. Horowitz and Sheth (1977) also found that convenience (along with time loss and reliability) was one of the most important factors in switching from SOVs to ridesharing modes.

Given the seeming importance of convenience in people's travel decisions, it is surprising that it has not been included more often in mode choice studies. One of the problems with using it is that researchers do not agree on what convenience is. Table 1 shows the elements that have been included in the definition of convenience in five studies that have used it in attempting to explain mode choice. The components that have been considered in each of the studies differ significantly. Many of the components are confounded with other dimensions of mode choice. For instance, "access time" and "short travel time" are usually included specifically as measurable elements of time in behavioral travel models. "Avoid undesirable areas" and "ride in safe vehicle" are usually elements of safety or security dimensions. "Protection from weather" is usually included as an element of comfort. People often talk and write as if a common understanding of convenience exists, but clearly it does not.

Stopher, Spear, and Sucher (1974) compared a simple measure of convenience, number of transfers required, with a scale derived from the components shown in Table 1. They found that both methods improved the ability of a model to explain travel choices. However, they maintained that the simple method was very limited and could easily lead to confusion with other variables.

Table 1. Definition of "Convenience"

	Stopher, Spear, and Sucher 1974	Spear 1976	Neveu, Koppelman, and Stopher 1979	Reibstein, Lovelock, and Dobson 1980	Mitchelson and Gauthier 1980
Start Trip					
Access time	X	X	X	X	X
Long hours of service					X
Frequent departure	X	X	X		
During trip					
Less changing vehicles	X	X	X		X
Few stops		X	X		
Short travel time	X	X			
Avoid undesireable areas	X	X			
Ride in safe vehicle	X				
End trip					
Little variation in arr. time	X	X		X	X
On-time arrival	X	X		X	
Easy access to final dest.	X	X		X	
Cost factors					
Easy payment method	X	X			X
Low cost	X	X			
Miscellaneous					
Avoid vehicle repair	X				
Protection from weather	X	X			X
"Easy to use"	X	X		X	
"Convenient"				X	

Given the discussion in the preceding paragraph, the more complex method also may suffer from confusion with other concepts. Westin and Watson (1978) segmented travelers into three groups on the basis of their responses to attitudinal questions: Economic, Convenience, and Amenity. The group names refer to the component that they tended to emphasize. The Economic group differed considerably from the other two groups in the way they made choices and the

outcomes. However, there were no detectable differences between the Convenience and the Amenity groups. The reason for this is probably in the ambiguity in definitions of the qualitative variables. In 1979, Neveu, Koppelman, and Stopher published a study that showed the difficulty in separating convenience from reliability and other qualitative variables. They argued that the reason was that the elements of convenience are time-related, as are some of the other qualitative variables.

There is some direct evidence that measures of convenience are confused with time factors. Henley, Levin, Louviere, and Meyer (1981) showed that people who had to transfer during a bus trip not only tended to have longer trips, but they **overestimated** the duration of the trip, compared with people who made fewer transfers. Williams (1978) interpreted the difference in people's value of time in walking to a bus stop compared with waiting as a difference in perceived convenience.

Other potential explanations of the confusion of convenience with other variables relate to the human decision-making process. Norman and Louviere (1974) demonstrated that if people have a very low evaluation of any single attribute of a transportation mode, they tend to evaluate the mode as a whole as unattractive. High evaluations on any other aspects do not make up for that low evaluation. Most transportation models assume that evaluations of modes are based on the sum of evaluations of individual components. If the additive model is not a correct depiction of the decision-making process, then the results would not clearly separate the importance of an attribute such as convenience if other attributes were overwhelming in the decision process.

Another question in human decision-making is the relative extent to which attitudes affect choice and vice versa. Reibstein, Lovelock, and Dobson (1980) showed that perception of convenience did not significantly affect mode choice, but that there was a very strong effect the other way around. People perceived their

usual choice as being the most convenient. However, when these researchers included an intervening factor, affect (or emotional response to a mode), in the model, they found that perceptions of convenience did have an impact on affect and that affect was strongly related to choice. They concluded that attitudes do cause behavior, at least indirectly, but that behavior was a much stronger influence on attitudes, especially in the case of perception of convenience.

Implications. In arguing for the inclusion of psychological variables in mode choice models, it is tempting to respond to the contradictory findings concerning convenience by simply looking for a better and more effective way of measuring it. However, the research during the past two decades on this attribute suggest another possibility. Perhaps combining disparate factors such as number of transfers and ease of fare payment into one concept such as convenience is fruitless. The better approach may be to separate those elements in the analysis and to consider the interactions among those elements as well as their interactions with other factors, such as perceived travel time, in the interpretations of the data.

What does the research say that can improve the design and promotion of different modes of transportation? Clearly, some of the components of convenience influence people's mode choice. It is important to concentrate on each of these components independently. First, in agreement with one of Stopher's (1977) arguments, independent consideration of the components means that research results can be tied directly to the physical or policy factors that can be changed to improve a mode's attractiveness in the most effective way. Second, combining the elements of convenience into one factor in a transportation model risks the confusion of convenience with other factors and may result in inconclusive outcomes. Third, we do not know enough about the relative importance of each of the elements of convenience for them to be really useful to planners and policy makers. Continuing to talk about convenience in the global sense will not improve this situation.

Comfort

Most of the comments that apply to convenience as an influence on mode choice apply to comfort as well. Studies of the importance of comfort have had widely disparate results. For instance, Nicolaidis (1975) found that mode choice correlated higher with a derived index of comfort than with either time or cost factors. On the other hand, Mitchelson and Gauthier (1980) found that comfort was the least important among nine factors that affect mode choice. This difference is probably due to the lack of a good definition for the concept.

Perception of comfort influences how people perceive the travel time for a trip. Henley, Levin, Louviere, and Meyer (1981) showed that car users who thought their trip was uncomfortable tended to overestimate travel time. Bates, Roberts, Gwilliam, and Goodwin (1987) found support for their hypothesis that the value of travel time was influenced negatively by the degree of comfort. Because of the influence of comfort on the perception of time, it is not surprising that comfort is confounded with other aspects of the trip. Neveu, Koppelman, and Stopher (1979) had trouble distinguishing among comfort, convenience, and reliability.

Researchers have attempted to develop indices of comfort on the basis of responses to specific attributes of modes. Oborne (1978) suggests distinguishing among three types of comfort:

1. riding comfort -- noise, vibration, temperature, etc.;
2. local comfort -- at stations, airports, or interchange points; and
3. organizational comfort -- good connections, frequent service, and reliability.

Table 2 shows specific attributes that have been used in attempts to develop indices. The first two studies (which show some agreement) were published in an ergonomics journal. The third one, which differs substantially from the other two, was published in a transportation journal.

Table 2. Definition of "Comfort"

	Manenica and Corlett 1973	Oborne and Clarke 1973	Nicolaidis 1975
Vibration	X	X	
Ventilation	X	X	
Temperature	X	X	X
Noise	X	X	
Seat comfort	X	X	
View out	X	X	X
"Comfort"	X		
Cleanliness		X	X
Weather protection		X	
Storage space			X
Few stops			X
Little fatigue			X
Privacy			X
Ease of access			X

Researchers have often mentioned the importance of including measurements of perceptions of comfort in mode choice studies (e.g., Hartgen and Tanner, 1971; Ross, 1975; and Stopher, 1977). Understanding the importance of different aspects of comfort for different market segments would help in the design and promotion of transportation alternatives. For instance, Nicolaidis and Dobson (1975) conducted research to assist in the design of the Detroit people mover. They found that people who had high incomes, had more education, and were white tended not to prefer luxury travel over good prices and service. Knowledge such as this can assist designers and marketers in reaching ridership and cost recovery objectives. However, knowledge of the influence of the comfort variable has seldom been used in this way.

Reliability

Planners have long assumed that reliability is important to people when they make transportation choices. The definition of this attribute is fairly well agreed upon. It is simply the amount of time variation people experience in each segment of their trips. However, variation can result from a variety of sources. For instance,

the arrival time of a bus to its destination can be affected by highway congestion, the number of stops required, the number of passengers boarding or alighting, the driver's vehicle control patterns, accidents, breakdowns, and so forth. Even though the variability can be measured fairly precisely, people's reactions to it may vary widely.

Most research supports the hypothesis that reliability is an important component of the mode choice decision. Paine, Nash, Hille, and Brunner (1969) found that, even though people were equally satisfied with the reliability of transit and auto, reliability was the most important attribute used in making mode choices. Jessiman and Kocur (1975) concluded that reliability was more important than travel time, cost, comfort, or safety for work trips, but that it was not as important for other types of trips. On the basis of their research, Horowitz and Sheth (1977) maintain that reliability is one of the most important aspects to consider in encouraging a shift to ridesharing modes. Bates, Roberts, Gwilliam, and Goodwin (1987) showed that the people's perception of the value of time is affected by predictability or reliability.

Some research has raised questions about the importance of reliability, however. Neveu, Koppelman, and Stopher (1979) showed that distinction among reliability, comfort, and convenience is difficult. In fact, as shown in Table 1, many researchers consider reliability to be one of the components of convenience. Fenwick, Heeler, and Simmie (1983) compared different mode attributes and found that reliability was the least important aspect among the those they considered. They used a conjoint measurement technique with two reliability levels, described as "always on schedule" and "have to allow for delays." The two price levels they used were $10 and $25 per week. Their results may have been an artifact of their experimental design (using such disparate cost levels).

Very little research has been devoted to a detailed study of the components of reliability. One exception is research conducted by Prashker (1979). He used

psychometric scaling techniques to determine the relative importance of travel time, waiting time, and parking time reliability. In addition, he explored the importance of eight other specific attribute definitions:

1. "means of travel will be available when expected at the starting point of the trip;"
2. "able to estimate the actual time of arrival at destination";
3. "travel in a vehicle whose travel time is unaffected by traffic congestion or frequent stops";
4. "to get to destination as fast as possible";
5. "during the summer, to travel in a vehicle whose travel time performance is not influenced by weather";
6. "during the winter, to travel in a vehicle whose travel time performance is not influenced by weather";
7. "to have no stops for repairs of vehicle"; and
8. "to arrive at destination without accident."

He found that out-of-vehicle reliability was more important than in-vehicle reliability. He also found that, for car users, parking reliability was more important than other in-vehicle time.

Reliability is closely tied to travel time. Even though one can statistically distinguish between average travel time and the amount of variation in travel time, people's perceptions of the two attributes are likely to be intertwined. Furthermore, even though no research proves this hypothesis, people's perceptions of variations in travel time are likely even more distorted than their perceptions of travel time itself. Since evidence shows that reliability is important in mode choice, it is critical to include measures of reliability in mode choice studies.

While little is known about the dynamics of people's perceptions of reliability, and actual measures of reliability are seldom measured or included in mode choice models, the concept does enter into design decisions. One of the motivations behind the construction of HOV lanes, for instance, is to provide a reliable as well as a faster trip for transit, carpools, and vanpools. Transit systems

generally monitor and encourage on-time performance. However, the general public is probably not well aware of the comparative reliability of different modes. Perhaps single occupant automobile travel is less reliable than other modes, even though general perception is otherwise. This fact could prove to be an important element of promoting transit and ridesharing.

Safety

Perceptions of safety have played a role in some of the past mode choice research. Nicolaidis (1975) urged the inclusion of measures of perceived safety in any effort to understand or predict mode choice. Belohlav and Shell (1980) studied the importance of several factors, some related to the mode and some related to the individuals making the choice. They found that "attitude toward safety" was the most important factor affecting mode choice. Stopher, Spear, and Sucher (1974) included items representing safety ("avoid undesirable areas" and "ride in safe vehicle") as significant components in their measure of convenience. The overall measure was related to mode choice. In a survey of 225 elderly people at senior centers in Philadelphia, Patterson (1985) found that fear of crime on buses and at bus stops was a significant deterrent to using the bus. Interestingly, the more frequent riders had a higher fear of crime than less frequent riders. On the other hand, Horowitz and Sheth (1977) used measures on 10 attributes to distinguish between carpoolers and non-carpoolers, and they found that the only one that was insignificant was the "safe-from-crime" dimension.

Even though attention has been given to the influence of safety on mode choice, little research has been conducted to identify how people perceive safety aspects. One exception is Hoag and Adams (1975). They found that people perceive public transportation to be more dangerous than it really is and speculate that ridership has suffered as a result. Even though people often rate flying as safer than driving in questionnaires (e.g., Levin and Herring, 1981), clearly safety plays an important role in the decision to fly. In research documenting the "instant"

carpooling phenomenon in the Washington, D.C., area. Gellert and Reno (1988) speculate that people's willingness to enter a car with three other strangers (compared with one other person) is due to safety considerations. The "instant" carpool phenomenon would not work as well where the definition for a carpool is lower.

Clearly more research into the influence of perceptions of safety on mode choice is warranted. However, in the meantime, people promoting transit and ridesharing should document relative safety records and use the results to provide good information on which people can make decisions. For instance, Horowitz and Sheth (1977) found that carpoolers tend to be older, in larger families, own larger cars, have lived for a longer time at the same residence, and have worked longer at the same place of employment. All of these factors are related positively with safer driving.

Privacy

One of the attractions of using the automobile is privacy. To the extent that people value privacy over contact with others, this factor may be an important determinant of mode choice. In fact, mode choice research that has explicitly included privacy has supported its importance. Mitchelson and Gauthier (1980) found that privacy was third (after "physical effort" and "monetary expense") out of nine characteristics that can affect mode choice. In a study comparing Dutch car and train commuters, Bronner (1982) found that privacy was more important for car users than train users. In fact, he interpreted the results of his research to show that, for car users, if privacy of an alternative mode was considered insufficient, no other positive attribute could make up for it.

Privacy is important to most people, but it can be interpreted in different ways. Adler and Adler (1984) studied the socialization aspects of carpools for school children who commuted to work. They interpreted it as

> . . . a "cocoon of private space," isolating its occupants from contact with strangers. With barriers both symbolic and real, it separates children from the sounds, smells, and, for the youngest children, even the sights of the outside world, turning them inward toward each other. This restrictiveness intensifies the physical and emotional intimacy of their contact. (p. 201)

In other words, there is an element of "group privacy" even in ridesharing modes. Shlechter and Gump (1983) analyzed the impact of teenaged males' access to automobiles on their maturation process. They concluded that the privacy and independence of the automobile helped them accomplish the shift from childhood to autonomous adulthood. In a discussion of themes describing people's relationships to automobiles, Sachs (1983) identifies one image of the self that it satisfies as "master of time and space." People use the automobile to support their image of independence from others. These psychological aspects of the use of automobiles are discussed in more detail in a later section of this report.

Privacy has been identified by some (e.g., Nicolaidis, 1975) as an element of comfort. It is clearly important, especially in our culture. More research on the importance of privacy and how it is perceived is certainly called for. One fruitful avenue is to follow up Bronner's (1982) suggestion that people who choose to travel alone by car have a different way of evaluating privacy than do others.

The importance of privacy should not mean that the promotion of transit or ridesharing modes is hopeless. The fact that privacy does not necessarily mean the privacy of a single individual, but sometimes refers simply to isolation from strangers, means that the desire for privacy can actually be used to good effect in ridesharing programs. For example, the comraderie of a vanpool is not necessarily the opposite of privacy but helps fulfill needs related to isolation and protection from strangers. The design of buses should allow people to feel like they have their own territory in the midst of strangers to the extent possible. The importance of privacy simply means that it needs to be considered in the design and promotion of transit and ridesharing modes.

SOCIOECONOMIC CHARACTERISTICS OF INDIVIDUALS AND HOUSEHOLDS

A model of mode choice that assumes that all individuals and households respond to the same travel decisions in the same way is clearly a simplistic and naive model. Even though few models neglect individual and household differences in travel decision-making, there is no agreed upon way to account for them. Some models treat these differences in exactly the same way they treat differences among modes, as simply another element in the equation. Other, more complex models, such as the one illustrated in Figure 1, hypothesize that individual and household differences enter the decision-making process at specific points in the model. Other researchers develop separate models for different types of individuals and households. This section of the report deals with socioeconomic and demographic differences. The sections after this one cover psychological and cognitive differences.

Undoubtedly, socioeconomic factors play a role in travel decisions. Large scale trends in travel patterns can often be accounted for by changing demographics. Arguing from the perspective of activity analysis, Koppelman (1988) explains the development of new travel patterns with changing demographics, especially the changing division of roles between men and women in our society and the restructuring of the household away from the traditional nuclear family. Prevedouros and Schofer (1989) explain the increase in suburban congestion with the following factors:

- decreased household size,
- an aging population,
- more "returning young adults," and
- more never married people.

In addition to the large scale trends, demographic factors have been used to explain individual travel decisions, including mode choice. However, controversy exists about how to use socioeconomic variables.

Importance of Demographic Variables

Several researchers have studied the relative importance of demographic factors directly. Aldana, de Neufville, and Stafford (1973) assumed that demographic variables could be used to segment the population and develop separate models for mode choice. They used life cycle stages and social class to distinguish among travelers. They employed seven life cycle stages: young bachelors; childless, young couples; couples with small children; couples with teenagers or adult dependents; broken families; childless, old couples; and single, old persons. Only two social classes were found to be significant: white- and blue-collar workers. Using a combination of life cycle stage and social class, they identified 14 segments. They found that mode choice models developed for each segment were significantly different from each other.

Nicolaidis and Dobson (1975) conducted a study of attitudes related to people movers. They defined five groups of people on the basis of similarities of attitudes toward different attributes of people movers. They also found that the five groups differed considerably according to race, education, and age and to a somewhat lesser extent according to income and auto license possession. Costantino (1975) conducted a study of transit usage in several large cities across the United States. He used data at the census tract level and found that average demographic variables in the census tract were related to average transit usage within that tract. However, he also found that relationships were different in different parts of the country. For instance, he found that

- the number of blacks in a census tract was related to transit usage only in the eastern and north central states,
- the number of CBD workers was related to transit usage only in the western states,

- the number of females in the work force was related to transit usage only in the north central states, and
- the number of multi-family dwelling was related to transit usage only in the southern states.

Market researchers often urge the development of different models for different segments in order to promote the transferability of the models to different places. Costantino's research shows that caution should be used in transferring models across regions.

Demographic Influences on the Value of Time

One of the explanations for the influence of demographic factors on travel decisions is that they influence how time is valued. Theoretically, the value of time should be related to the income that alternative uses would generate. Therefore, one could postulate that time would be more valuable for people with higher incomes. Thomas and Thompson (1971) measured the value of time for different income groups and published tables showing specific values for specific incomes. Cherlow (1981) corroborated this finding in a review of several studies of the value of time. More recently, Bates, Roberts, Gwilliam, and Goodwin (1987) hypothesized that the value of time is influenced by a number of personal and household characteristics. They state that

> . . . it is invalid to treat individuals as if they were acting as independent economic units. There are three separate major problems here: the allocation of available income among members of the household, the interdependence of time constraints among household members, and the issues of group travel. (p. 51)

Impact of Specific Demographic Factors on Mode Choice

When demographic factors have been included in studies of mode choice, they often have a direct bearing on outcomes of choices. However, as will be discussed in more detail below, the particular relationship often has to do with study design and how the demographic factors are included. In this section, a few of the specific findings are presented.

Hacklander (1973) tried to determine the most important contribution to a person's definition of his or her life style. She used housing, food, clothing, transportation, and leisure as options. Transportation was the most important contributor overall, but it was especially important for people with high income. This finding supports the commonly-held assumption that income has an important impact on transportation choice. One of the most important impacts is on the number of cars owned by a household. That issue is covered in some detail below.

Dobson, Golob, and Gustafson (1974) studied the relationship between demographic factors and the importance of various attributes for a new public transportation system. Several specific findings emerged: people from families with an excess of licensed drivers over available automobiles place high importance on good service levels;

- married females with a high educational level placed high importance on amenity, aesthetic, and social interaction attributes;
- lower fares were considered most important by older people and individuals from large households;
- people with high education and high income did not place much importance on fares;
- married females were most concerned with privacy; and
- older people were least concerned with privacy.

One of the problems with this kind of research is the interaction among the demographic variables. For instance, high education tends to go with high income, and high income tends to be related to having an excess of automobiles over licensed drivers. Thus, the finding that people with excess automobiles place a high importance on good service levels is not very different from the finding that people with high education and income do not pay much attention to fares.

Studies of non-work trips have shown relationships with demographic variables that are not surprising. Gayler (1974) showed that people from higher social classes tended to travel further for frequently purchased shopping goods, such

as groceries. Hubbard's (1978) research supports this finding by showing that higher income people tend to travel further for shopping trips. He also shows that large households generate more frequent shopping trips, which is not surprising. Pas (1988) studied weekly travel patterns and found that low income people tend to have irregular patterns with fewer trips than high income people. Females tend to make off-peak trips with multiple stops.

Blankenship (1976) showed that people with high income and post-graduate educations were more willing to try new things than others. Pitts, Willenborg, and Sherrell (1981) supported this finding by showing that people with higher education and higher income responded to the gasoline price increases during the last decade both by downsizing their cars and by making fewer trips. The people who responded in these ways also tended to be white and from large households. The fact that people with more education and higher incomes respond to the economic environment may simply be due to the higher flexibility they enjoy because they have more disposable income and more control over their lives.

Lack of Importance of Demographic Factors in Mode Choice

The fact that so few of the studies reviewed for this report showed clear relationships between demographic characteristics and mode choice needs some explanation. One of the explanations is that demographic factors simply are not very important by themselves. On the basis of empirical results, several researchers have reached the conclusion that demographic variables are not important in the mode choice process. For instance, Tardiff (1976) studied the explanations for people's perceptions that different modes were available to them. He looked at three classes of variables: attitudinal, demographic, and system characteristics. Since the study was conducted in California, very few people felt that they were "bus captives." However, many felt they were "car captives." The only type of variable that predicted their perception was attitudinal. Neither the socioeconomic characteristics of individuals and households nor the attributes of the highway or

transit systems had an influence on people's perception that they were "car captive." Dobson and Tischer (1977) tested three models' ability to explain mode choice: (1) perceived system attributes, (2) socio-demographic factors, and (3) network time and cost. Only the first model was able to explain mode choice. Including variables from either of the other two models did not significantly improve the model.

Reibstein, Lovelock, and Dobson (1980) investigated the relationships between attitudes and behavior. They were interested in determining the directionality of cause, whether attitudes caused behavior or vice versa. The strongest relationship was in the direction of behavior influencing attitudes. This phenomenon will be discussed at length in a later section. The important fact for the current discussion is that they tested the influence of sociodemographic variables in their models. They postulated that income and the number of people, driver licenses, and automobiles in the household would affect attitudes toward different modes. They found no significant relationships. The problem may have been in the specification of the model. The specific demographic variables they chose can better be conceptualized as constraints in the choice and should be related directly to behavior (the choice itself) rather than to attitudes.

Most mode choice studies have concentrated on the choice between auto and transit. However, some research has failed to find demographic predictors of participation in ridesharing programs as well. Horowitz and Sheth (1977) found that demographic variables were poor predictors of ridesharing. Ayele and Byun (1984) found that gender, income, and marital status were not related to the reason people gave for joining ridesharing programs.

Automobile Accessibility

Several explanations are possible for the mixed results in trying to find relationships between demographic variables and mode choice. Some have already been covered. The influence of other phenomena such as the fulfillment of

psychological needs and the influence of individual differences in cognitive style, as suggested by Michaels (1980), will be covered in later sections. One explanation that relates to demographic variables themselves remains. That is the influence of automobile accessibility.

Research has consistently shown that automobile accessibility is a very important determinant of mode choice. Hartgen (1974) found that auto ownership predicted 70-80 percent of the variance in the choice between auto and transit use. Hsu (1975) showed that multi-car owners gave consideration to transit use before car purchase, but bias against transit became stronger after car purchase. Ben-Akiva and Richards (1976) found that the only socioeconomic variable that improved prediction in a disaggregate mode choice model was automobile accessibility. The other variables they tested included household income, number of licensed drivers, number of workers, number of adults, type of residence, and occupation of the head of household.

Tardiff (1977) studied the influence of attitudes on people's choices to use the bus and vice versa. He found that auto availability and occupation predicted the use of the bus, but that neither was related to attitudes. Biel (1978) found that the only socioeconomic variables that predicted mode choice were automobile accessibility and whether a person was the head of the household (which also influences automobile accessibility). Williams' (1978) research showed that auto availability was the most important influence on mode choice. While income had no direct independent relationship to mode choice for work trips, it did influence mode choice for shopping trips.

Studies that showed relationships between demographic variables other than automobile accessibility and mode choice usually failed to include any consideration for the number of automobiles. For instance, Green (1973) found that, of occupation, race, income, and education, only income was an important determinant of the choice between subway and car. He used no information on car ownership,

and income was probably the best indicator of automobile accessibility among those factors he considered. Parody (1977) also failed to include automobile accessibility in a logit model of mode choice and found that gender and occupation entered significantly into the model. They probably served as surrogates for auto ownership.

Automobile accessibility is determined by several factors, including the number of autos in the household, the number of licensed drivers, the number of working adults, and household decision rules for who has access to the automobile. Lerman and Ben-Akiva (1974) used number of cars per licensed driver in combined models of auto ownership and mode choice. They developed separate models for nine market segments defined by four life cycle categories and two occupational groups. The four life cycle categories were

- households consisting of single persons without children;
- households with a married couple, both of whom were younger than 45 years without children;
- households with children; and
- households with a married couple, one or more of whom were older than 45 years without children.

The two occupational groups were households with primary white collar or blue collar workers. The ninth segment consisted of households with no full-time workers. The models were different for each of the segments. The authors conclude that

> Car-ownership decisions are made on substantially different criteria by different households depending on their life cycles and occupations. The failure to adequately reflect these behavioral differences in a model will result in inaccurate and possibly misleading forecasts and will fail to adequately represent the distribution of changes in car ownership over various socioeconomic groups. (p. 49)

In a later study by Ben-Akiva and Richards (1976), a different joint model of auto ownership and mode choice was developed that took into account the distribution of

the automobile among household members. The study employed four separate models:

- a combined model of auto ownership and primary worker's mode choice,
- a model of secondary worker's mode choice,
- a combined model of auto ownership and mode choice for households with no workers, and
- a model of frequency and mode choice for shoppers.

In that study, the only important socioeconomic variable was automobile accessibility. Ben-Akiva and Atherton (1977) used the same four-part model to study the influence of different strategies for increasing carpooling.

Henry (1976) studied the demographic correlates of the purchase of different sizes of automobiles. He used full-size, intermediate, compact, subcompact, and sports cars as the categories and found the following significant results:

- older people own more full-size cars,
- families with children own more subcompacts,
- higher income people own more full-size and fewer intermediate cars,
- more drivers per household means owning fewer full-size cars and more compacts, and
- households with more cars tend to own more intermediate size cars.

These findings may well be out of date by now; however, certainly demographic variables have an influence on the types and numbers of automobiles owned by a household. An international study by Uusitalo and Djerf (1983) showed that real income was highly related to auto ownership. Mannering and Train (1985), in an excellent review of auto purchase behavior, point out that the number and type of autos owned by a household are also related. They also point out that the number of automobiles owned by a household is influenced by the number of miles driven, as well as vice versa. In other words, once the auto is purchased, there is an incentive to use it.

Summary

Research on the influence of sociodemographic characteristics of individuals and households on mode choice has had mixed results. However, one theme runs through the literature. The most important characteristic is automobile accessibility in a household. All other demographic variables appear to operate through this one. To the extent that those factors influence auto ownership, the number of auto users in the household and the household's decision rules for use of the auto(s), they affect mode choice. However, there is very little evidence that they have a direct affect on mode choice independent of automobile accessibility.

Any research on mode choice must account for household decisions on auto ownership and auto use. Taking the number of autos in the households as a given is one approach. In that case, it is only important to gather information on how the car is used. For instance, if two workers in a household own one car, questions should target who uses the car and under what circumstances the car is shared. In any household, it is important to determine who makes what kinds of non-work trips and how those trips are combined with work trips.

A second approach to including sociodemographic variables in mode choice studies is to develop joint auto ownership and mode choice models such as those by Lerman and Ben-Akiva (1974) and Ben-Akiva and Richards (1976). Understanding the dynamics of auto ownership is a key to understanding mode choice. Once the decision to purchase an automobile has been made, the household has accepted the costs for depreciation, insurance, and probably maintenance as well. As the research on perceived cost of operating the automobile has shown, people generally consider these costs to be sunk costs and make usage decisions based on relatively small marginal costs such as gasoline, oil, and parking (if they have to pay for it).

For people involved in the promotion of transit and ridesharing, an important lesson can be learned from this research. In designing promotional strategies for alternative modes of transportation, the emphasis should not be on

saving the costs of operating automobiles (with the possible exception of parking cost) but on the costs of owning them in the first place. The targeting of promotional campaigns should consider which audiences are prone to appeals emphasizing owning different numbers and types of automobiles. It should also account for the types of households that have flexibility in the ways that auto use is allocated.

NON-DEMOGRAPHIC DIFFERENCES AMONG INDIVIDUALS

In the last two sections of this report, the emphasis has been on characteristics of modes, individuals, and households that are observable and measurable. However, some differences among people account for different decision-making processes that do not fit easily into an economic model of human behavior. Values, beliefs and psychological needs enter into the decision-making process. If they are not accounted for, the relationship between choices and the more easily observed factors can be obscured. The inclusion of this section does not necessarily mean that measurement of these types of variables should be included in all mode choice studies or in the design of promotions, but that awareness of them is critical in interpreting other results.

In their critique of disaggregate travel-demand models, Bullen and Boekenkroeger (1973) pointed out the limitations of utility models:

> . . . personal travel is an extremely complex process. . . . [It is] the realization of human activity structured over a spatial framework. The analysis of these spatial connections is the travel modeling problem and, as such, it has been frequently and clearly described throughout the literature. This initial characterization, however, is frequently followed by a precipitous leap to the description of rational economic man as a utility maximizer. At most, strictly qualitative attention has been given to the concepts and subsequent assumptions that transform the former into the latter. (p. 41)

If the automobile serves other than utilitarian needs, what are they? Reser (1980), in his analysis of the automobile's popularity makes the case that the costs of using the automobile are extremely high. He concludes that

> The seeming insensitivity to costs and inconvenience would suggest that the private car is serving other than utilitarian needs . . . convenient transportation, perceived freedom and autonomy, sexual and aggressive symbolic expression, status and identification value, and familiarity and security . . . and individual control over the environment. (p. 281)

Others, however, suggest that, in order to understand travel behavior, one must understand the decision in the context of the total range of human activity. Michaels (1981) asserts that transportation only assists in people's attempt to satisfy other needs. He says that

> . . . travel and transportation are mediators between needs and satisfiers. In this sense, transportation has an intrinsic cost. It delays need satisfaction and adds an increment to the energy expended to obtain satisfaction. Travel has no direct benefits; it has indirect benefits in the sense that it can increase the alternative sources of satisfaction available to the individual and the social group. (p. 245)

Koppelman (1988) supports this view from activity-based travel analysis and points out that travel is not the core of human behavior. However, it is a response to a wide range of personal and social needs and ". . . thus, the study of travel behavior can provide useful insights into the development and satisfaction of these more basic needs." (p.58)

In his essay on the meaning of the automobile for individuals, Sachs (1983) asserts that automobiles actually reflect society's values.

> Most objects in a given society are only to be fully understood if their immaterial qualities are taken into consideration: just as you don't drink champagne only to quench your thirst, there is not much sense in building gothic cathedrals merely in order to protect the faithful from the rain. Thus, objects stand for cultural conceptions. On the other hand, cultural meanings need to be anchored in objects in order to be durable. Whereas in non-industrial societies meanings are often incorporated into objects of nature like trees or mountains or in objects of art like votive tablets or castles, in industrial societies the goods and services which are offered as commodities tend to take on that role. Therefore we can expect the automobile to carry basic traits of our cultural understanding. (p. 349)

No matter what point of view one accepts, clearly values, beliefs, and psychological needs are related to transportation decisions. This section of the report deals with these issues.

Values

Values are deep-seated beliefs that guide human behavior. In the psychological literature they are distinguished from attitudes because they are not attached to any specific object. Attitudes are beliefs about specific objects. Values are general beliefs that are usually conceived of as being antecedent to attitudes and are responsible for their formation. However, some researchers (e.g., Zajonc, 1980) have argued that affective reactions, such as those represented by values, are primary, basic, difficult to verbalize, and may not involve cognition. In other words, there may be no causal connection between values and attitudes.

Rokeach has conducted numerous studies of values and their impact on human behavior. He developed a list of 18 basic values (Rokeach, 1973) that represent the range of dimensions for value measurement. These values have been used in a wide range of research studies. They have also been applied to transportation decision-making. For instance, Tan and Kundrat (1976) found that bus riders could be distinguished from non-bus riders on the basis of two value dimensions. They tended to evaluate "equality" very high and "freedom" very low. Pitts, Willenborg, and Sherrell (1981) found that "family security" was a strongly held value among those who downsized their cars and reduced driving in response to the gas crisis of the 1970s. Those who did not respond placed a high value on "a comfortable life" and "an exciting life."

Henry (1976) used a different set of values (Kluckhohn and Strodtbeck, 1961) to investigate the impacts of values on the size of cars owned. The four dimensions in this value orientation were

1. man's relation to nature -- subjugated by, in harmony with, or having mastery over;

2. time dimension -- oriented toward the past, present, or future;

3. personal activity -- emphasis on enjoyment of life, learning, and self-fulfillment or on results; and

4. man's relations to others -- a family and patriarchical orientation, a collective democratic orientation, or a basic individualistic stand.

He found that full-sized autos tended to be owned by people with a family or patriarchical orientation toward others and a feeling that they were subjugated by the world. Intermediate sized cars are favored by people with democratic orientations toward others, whereas compact cars are least favored by people with this orientation. The exact relationships between values and car size are not very important, especially since the relationships have probably changed considerably since then. However, values do have a significant effect on the size and number of cars a family owns.

Personality Types

A small body of research relates personality traits with transportation decision-making. Two research studies used "responsibility attribution" or "locus of control" to explain aspects of travel decisions. Rotter (1966) defined two dimensions of responsibility attribution, Internal and External. People with an Internal locus of control generally feel themselves able to control their fates, while Externals feel themselves relatively unable to control their outcomes. This dimension of personality has been used in numerous studies of attitudes and behaviors. Two are directly relevant to transportation decisions.

The first was based on previous research that showed that people's response to stress was determined to some extent by their belief about control in threatening situations and over the environment in general. Hoyt (1973) hypothesized that people who were high on an Internal locus of control measure would report less anxiety about traveling via automobile than would Externals. This hypothesis was confirmed. Hoyt did not test the differential response to stress for other modes, but one would expect Externals to avoid driving automobiles under congested

conditions more so than Internals. Hoyt also found that Internals tended to experience automobile travel as more interesting and involving than did Externals.

Sherman, Perez, and Sherman (1981) used the same measure of locus of control to examine motorists' behavior with respect to conserving gasoline. Other research has shown that Internals are more likely to participate in efforts for social change, because they feel they can have some effect on outcomes. The authors hypothesized that Internals would be more likely than Externals to

1. state a willingness to reduce their amount of driving,
2. be willing to use alternative modes of transportation, and
3. perceive industrial and governmental measures for alleviating the gasoline shortage to be effective.

The second hypothesis was **not** confirmed. Externals were significantly more willing to carpool or use the bus than Internals. The authors had two explanations for this unexpected finding:

1. Internals tend to have higher incomes and therefore, for other reasons, be more likely to drive alone; and
2. Internals have a higher need to be independent and in control, making them less willing to depend on others for their transportation.

A third reason may be related to Hoyt's findings that Internals simply can take the stresses of driving alone better than Externals.

What can we learn from these, admittedly skimpy, findings concerning mode choice and locus of control? They point out that caution should be exercised when people's environmental concerns are appealed in an attempt to promote ridesharing and transit. People who may respond to environmental messages may also be people who, for other reasons, are not likely switch to travel modes that require depending on other people. Secondly, both in conducting research and designing promotions, we should be sensitive to the fact that there are individual differences in people's perceptions of their ability to control outside forces and that these differences have implications for how they make decisions. We should not assume,

for instance, that everybody feels that their own decisions have an impact on the transportation environment.

Another dimension of personality has to do with flexibility or open- and closed-mindedness. Blankenship and David (1976), in their study of the interactions of carpoolers, noted the importance of compatibility among the members of carpool groups. They found that flexibility is the most sought after personal characteristics among fellow carpoolers. One of the major objections to computer-based matching programs is that relatively subtle personality attributes such as flexibility are difficult to detect without face-to-face meetings.

Marks (1979) studied the relationship between environmental protection behaviors and the psychological variables of self-esteem, open- and closed-mindedness, and inner- and other-directedness. She found that open-mindedness is related to the use of alternative transportation modes, especially among males. These two research studies show that people with flexible personalities are not only more likely to participate in ridesharing, but they are also more likely to deal successfully with the personal interactions that result.

In another study, Greenberg (1978) found that endorsement of the Protestant work ethic was related to how commuters perceived their commute time. Those who endorsed it perceived their commute as work time. If it was possible, they used the time to actually work. If not, they were more likely to value the time at the same rate as they were paid. In designing promotions for carpooling, vanpooling, or bus commuting, it is important that promoters remember that not all people will respond to the message these modes afford relaxation time.

Dealing with Stress

Travel has the potential to raise stress levels. Since people deal with stress in different ways, the influence of stress on transportation decisions is an important individual difference that needs to be considered. Most people assume that solo driving in congested conditions is the most stressful kind of traveling that occurs.

People might also assume that long distance train or bus travel would be the least stressful. However, Tainsh and his associates (Tainsh and Winzer, 1975; Tainsh, 1975; and Tainsh, 1977) showed that performance in logical thinking got worse and physical symptoms of stress increased in long distance travel by bus or train. Car riders in similar situations showed fewer symptoms of stress.

Stokols and his associates (Stokols, Novaco, Stokols and Campbell, 1978; and Stokols and Novaco, 1981) conducted a series of research studies of the effects on health of transportation alternatives. They measured perceptions of commute trips in terms of "impedance." Impedance was measured by a combination of distance and duration of the commute. Not surprisingly, high impedance was associated with subjective reports of congested traffic and annoyance. Impedance was significantly associated with high blood pressure for the experimental group as a whole. However, people who exhibited Type A behaviors (extremes of competitiveness, impatience, and job involvement) reacted differently to high impedance commute trips than did those who exhibited Type B behaviors (noncompetitive, patient, relaxed). Type As exhibited less stress under high impedance conditions. The researchers speculated that this was primarily due to the fact that Type As accommodate to high impedance trips better than do Type Bs.

Stress is a factor in transportation decisions, and people vary in what they find stressful. Some people find driving alone in congested conditions extremely stressful, while others may be able to relax and enjoy the private time. Some people find comfort and relaxation in the contact with other people in ridesharing situations, while others find the contact with others during the commute to be extremely stressful. These differences are bound to have an impact on people's willingness to try different transportation modes. While there are no ways to easily identify these people, it is important to consider the fact that people differ on this dimension.

Needs Satisfaction

The fact that transportation choices serve needs other than getting from one place to another is not a new observation. People's behavior and Madison Avenue appeals to buy different kinds of automobiles make obvious the fact that other motivations are involved in these decisions. Also obvious is the fact that people vary considerably in the extent to which transportation choices fulfill psychological needs. Perhaps partly because these observations are so obvious, little rigorous research has studied the phenomena. However, the work that has been done confirms the fact that the fulfillment of psychological needs is important.

One of the themes in the psychological study of transportation decision-making is the need for independence. People have assumed that the popularity enjoyed by the automobile can be accounted for partly by the independence and freedom that it offers. In today's congested conditions in urban areas, however, the freedom is not quite so apparent. Twenty years ago, Paine, Nash, Hille, and Brunner (1969) found that the perception of independence was one of the most important factors that distinguished bus riders from automobile commuters. The distinction might not be so obvious today.

However, undoubtedly, independence and freedom are important, especially in our culture. Fine (1975) showed that for the elderly, mobility was one of the most important factors that determined their health and satisfaction with life. Reser (1980), in an excellent essay on our addiction to the automobile, attributed our use of the automobile beyond what seems to be economically rational partly to the independence that it allows us.

Shlechter and Gump (1983) conducted research on male adolescents and their use of the automobile. They found that unrestricted access to an automobile seemed to have a positive impact on the boys' lives. They engaged in more socially responsible behavior and, in general, demonstrated higher levels of maturity than

those who did not have access to a car. Three hypotheses to explain this difference were offered:

1. since environmental exploration and experimentation helps form a healthy ego identity, driving has a positive impact on identity formation;

2. driving helps teenagers form new and more solid relationships with peers of both sexes; and

3. along with driving comes a degree of autonomy and independence from parents that helps the shift from dependent childhood to autonomous adulthood.

The positive impacts from this independence may carry over into people's later feelings about automobiles.

Schlechter and Gump's findings also suggest a function of the automobile that is opposite of independence and freedom. That is the need for community. In some situations, the automobile becomes the focus of community. Levin and Gray (1979) analyzed interpersonal influences in the formation and promotion of carpools. They found that the desirability of carpooling increased with more acquaintances as part of the carpool. Having the carpool composed of all acquaintances was the most desirable, followed by having at least one acquaintance. The success of carpooling and vanpooling has often been related to the development of small cohesive "communities."

The Friday night "drag" is another example of the automobile becoming the center of a community in our culture. Harrison (1978) provides an interesting account of how the automobile was also the center of communal activities in Bahrain. On Friday afternoons, thousands of Bahrainians would drive 15 miles out of town to an abandoned airstrip. Some would park along the side and others would cruise up and down the strip. Most of the cruisers were

> . . . entire families, with the father driving, older children with him in the front seat, the mother in her black *aba* with the younger children in the rear. They come in Toyotas and Datsuns and sometimes cram an incredible number of people into the little cars. There are no age limitations: there are young fathers and elderly patriarchs. All the

> families are obviously having great fun, smiling and laughing as they drive up and down the asphalt. (p. 56)

The other groups include young single men, who tend to drive large cars that are

> . . . lovingly polished to concourse brilliance and are often decorated with extra chrome, outsize hood ornaments, tassled curtains in the windows and always that almost universal Bahraini accessory, a custom-fit, pastel-colored swath of artificial sheepskin draped over the dashboard . . . They like to drive slowly up and down the airstrip looking straight ahead -- or pretending to look straight ahead. They spend less time than others parked by the side watching the traffic go by, although groups of friends from three or four cars may be seen in animated conclave between their gleaming vehicles along the verge. (p. 56)

The young women tend to come in pairs and spend most of their time by the side, observing. They never visit with the young men. The social function in this account is obvious.

It also suggests another need that is satisfied by transportation choices, self-expression. Bolton (1979) describes Peruvian truck drivers and applies anthropological analysis to the way they decorate their vehicles. In Peru, the trucks carry goods from village to village on semi-regular routes, but they also serve another purpose. They are the equivalent of an intercity bus line. They take passengers, for a fee, on the same routes. Since very few people own private vehicles, they are the only mechanized way to get around in the rural areas of Peru. In addition to the driver's name and their destination, most of the trucks are painted with elaborate decoration. Bolton analyzed the mottos on the trucks, which included religious themes (e.g., "God is my guide" and "God delays but does not forget"). The predominant themes, however, are related to "machismo." Examples, including the general dimensions of "machismo," are:

- "Super male from Acomayo" (power)
- "Envy consumes you on seeing me" (envy and hatred)
- "The pride of my homeland" (self-praise and bragging)
- "Doesn't earn but does enjoy" (enjoyment of life)

- "Pass, stranger without destiny" (aggression and insults)
- "A lover in every town" (sexuality)

Even though few people in our culture put such obvious mottos on their cars, the type of automobile a person drives expresses their personalities as clearly. Consider the difference between the self-expression inherent in a Toyota station wagon and a Maserati.

Research has been conducted on the associations that people have between types of automobiles and other characteristics. For instance, Gibbins and Coney (1982) showed that people had consistent opinions about the types of people that would be likely to own certain types of automobiles. They suggested that the slow change in auto body styles allows complex associations to develop between types of cars and owners' personalities. Erickson, Johansson, and Chao (1984) demonstrated that the country of origin of an automobile had a demonstrable effect on people's beliefs about the product.

In Sachs (1983) essay on the cultural meaning of the automobile, he identified four dimensions of self-expression that the automobile allowed:

1. "master of time and space" -- the image of an independent life-style,
2. "speed, rivalry, power" -- the thrill of speed and the feelings of omnipotence and virility,
3. "possessive narcissism" -- possessing the latest technology means participating in history and the advancement of technology,
4. "social superiority" -- from the beginning, the possession of a car implied higher social status.

He concludes his essay by pointing out that the automobile is losing its power of self-expression in all these areas because of increased congestion, environmental impacts, and almost universal auto ownership. However, these functions still have an impact on people's transportation decisions.

Reser (1980) pointed out one of the neglected ways that automobiles satisfy needs, namely, control over the environment. The automobile is probably the most

complex technology that most people ever have a chance to control by themselves. The control over the environment that the auto offers through mobility is reinforced by the ability of people to control the machine itself.

Dieckmann (1976) discusses the symbolism of the automobile in dreams and comes to the conclusion that automobiles can represent something more basic than social status or mastery over the environment.

> As well as a simple status symbol or as the symbolic expression of automatic ego functions or as energy filled representations of the instincts and the drives, [the automobile] can also be an expression of the whole human personality, extending to our bodily, spiritual and technical creativity. (p. 35)

He reports on dreams in which the auto represents God, the self, and elements of the self. He also describes two cases in which the development and improvement in automobiles was related to the development and improvement of individual's egos. The centrality of the automobile in some people's self-perception is dramatic.

This section has concentrated on the importance of automobiles on needs satisfaction, primarily because that has been the area in which most of the research has taken place. It is surely important that the tremendous attraction of the automobile be considered. These needs will always exist, at least for some parts of the population. Therefore, the design and promotion of alternative modes of transportation should take account for these needs. As Reser (1980) asserts,

> What may ultimately be needed is a design concept (in alternative transportation) which maximizes perceived and actual control over the immediate physical and social environment, and at the same time reduces the impact and number of environmental stressors and demands. (p. 286)

Summary

The importance of individual differences in transportation decisions is apparent. Some of these differences are not related directly with easily observable characteristics. While psychological and cultural differences may be correlated with demographic variables, they do not vary directly with them. Even when all

demographic and situational variables are considered, people vary in how they make decisions. Some of that variation can be explained by the factors discussed in this section. It may be impractical to measure these differences in planning-oriented research, but it is important that the differences are accounted for in the interpretation of research results or in promotion design.

COGNITIVE PROCESSES

In the beginning of this report, several mode choice researchers were quoted as saying that traditional mode choice models are deficient because they do not represent the actual decision-making processes that people employ. So far, this report has covered the importance of accounting for perceptions, demographic differences, and individual variations in more psychological dimensions. Another set of factors that should be considered consist of the cognitive processes that people employ. How do people account for their perceptions, their circumstances, and their needs and actually make a decision?

Researchers have been challenged to add to our understanding of this process for many years. Hartgen and Wachs (1974) ended a critique of disaggregate behavioral travel demand models with suggested directions for research that included consideration of traveler evaluation mechanisms; the effects of memory, learning, expectation and habit; and the effects of external information sources. Jones (1979), in another critique of traditional behavioral modeling, pointed out that it does not include the effects of habit and that it does not account for discontinuities and threshold effects. For example, traditional models do not explain how people make a complete shift from one mode to another when the change in attributes is minimal or non-existent. More recently, Kitamura (1988) stressed the importance of travel patterns and the dynamic aspects of travel decision-making, especially the influence of habit.

Michaels (1980) emphasized the importance of understanding cognitive process in transportation decision-making.

> . . . [People] develop long-term mechanisms for sorting or coding information, storing and retrieving it, and evaluating it. Clearly, such processes must be increasingly subjective and internal and the connections to external and observable events increasingly mediated and indirect. In essence, past and future are symbolically mediated, as must be those processes that compensate for real time limitations. There are, then, increasingly complex transforms that people make, from the elementary and observational to the interpretative and predictive. Modeling these transformations has become a central focus of modern behavioral science. The most significant aspect of this course of development is its subjective focus on internal events rather than on objective, external behavior. It is a subjective world view, one that is concerned with quantification of qualitative properties. (p. 66)

Because of the importance of these internal processes, Michaels suggests that market segmentation should be done on the basis of cognitive process rather than traditional demographic factors. Mitchelson and Gauthier (1980) employed this means of segmenting the market and found that different segments had significantly different sensitivities to mode attributes.

The fact that people have different ways of gathering, processing, and storing information seems self-evident. These differences can certainly have an effect on the outcome in mode choice decisions. This section of the report covers the cognitive process in four parts:

1. combining multiple attributes,
2. how choice affects attitudes and perception,
3. using knowledge, and
4. the influence of habit.

Combining Multiple Attributes

One of the main debates in understanding cognitive process in mode choice is how people combine information among several dimensions and make one choice. For instance, every mode choice has some element of time, cost, and convenience associated with it. People have perceptions of each of these elements

and somehow weigh them with respect to each other and make a choice. Several models of this process have been proposed, and several different methods have been developed to represent the models.

First, we should ask why we consider multi-attribute models at all. In an early review of these types of models, Wilkie and Pessemier (1973) answered this question.

> The unique contributions with multi-attribute theories of preference and choice can make are found in the area of *design*. A model which cannot help analysts and decision-makers improve the characteristics of choice objects and/or their delivery systems is prone to be theoretically vacuous. On the other hand, a model that links the characteristics of choice objects and/or their associated delivery program to manifest preferences increases understanding and the capacity for favorable action. (p.439)

In other words, by considering the contribution of each mode attribute to the final decision separately, one can come to an understanding of how a new mode would be perceived and used.

Theoretical Issues. Usually there are two ways in which attributes are associated with modes. One is the degree to which the attribute describes the mode. This attitude has been measured in several ways, including

1. direct ("to what degree is a bus reliable?"),
2. satisfaction ("how satisfied are you with the reliability of a bus?"),
3. combination of (1) and (2) ("how satisfied are you that the bus is reliable?"), and
4. relative applicability ("is a bus more reliable than the auto?").

The second way that attributes are associated with modes is in the importance of the attribute to the person. In some research, the importance is determined by asking a direct subjective question ("How important is reliability to you?"). In other research, the importance of the attribute is **derived** from other questions. Gilbert and Foerster (1976) labeled these two approaches to determining importance "direct subjective rating" and "revealed preference."

No matter how the importance is determined, it is used in essence as a weighting factor that determines the degree to which the attribute contributes to the attractiveness of the mode to which it applies. The "generalized attribute variable" is the product of the importance and the degree to which the attribute describes the mode. Accounting for all the "generalized attribute variables" determines the overall attitude or preference for the mode. Most models simply sum up all the "generalized attribute variables" for each mode to represent the preference. Algebraically, if x_{ij} represents the applicability of attribute **i** to mode **j**, and a_i represents the importance of attribute **i** to the individual, that person's preference for mode **j** would be

$$\textbf{preference}_j = \sum_i a_i x_{ij}$$

As will be discussed below, however, this representation of the decision-making process is probably too simple.

<u>**Measurement Issues**</u>. The direct subjective measurement of importance of attributes is the traditional approach in mode choice modeling. Hartgen and Tanner (1970) proposed using such a model to test the impacts of changes in system attributes on system use. In Hartgen and Tanner (1971), they used survey data to test actual changes in attributes, including (1) increased bus cleanliness, (2) building a downtown transportation terminal, (3) introducing free transit, and (4) improving bus maintenance. Using survey data, they were able to test the impacts of these changes on different parts of the city. The results were reasonable, but the authors pointed out the main problem with this approach:

> . . . foremost is the absence of data that can aid in specifying the relationship between a system attribute and its various variable measures. Therefore, we were forced . . . to assume that changes occurred directly in the satisfaction levels of attributes and to use these as the means of inducing attitude change in the model. (p. 7)

The basic problem they found was that direct measurement implies asking questions about existing transportation systems. Applying the results to a system that is

different can be problematic and limits generalizability. In subsequent research, Hartgen (1974) found that attribute weighting had little influence on the predictive strength of the model and that situational contexts were the most important determinants of mode choice.

Spear (1976) used direct subjective measurement to model mode choice. Individual satisfaction with each attribute was determined from direct questions. The importance of each attribute of convenience was determined by combining individual's rank ordering of the importances into one scale. The two ratings for each of 14 attributes describing convenience were combined linearly to produce a "generalized convenience variable." This variable was added to time and cost variables in a logit function and significantly improved the fit of the mode choice model. The enhanced model would probably have performed even better, had the importance measurement for each attribute reflected individual, rather than group, ratings.

Most recent developments in the area of multi-attribute models of mode choice have employed "revealed choice" methodologies. The common theme for these types of models is that actual mode choice is used to derive the importance ratings for attributes. Several approaches have been taken to this type of model. For instance, Vanier and Wotruba (1977) derived importance weights using regression analysis. They first asked people to rate the degree to which several characteristics described bus systems on six-point scales. Then they asked people's overall ratings for the bus system. By regressing the characteristics on the overall ratings, they could estimate the weights for each characteristic. This method assumes that the weights are the same for all people, however.

Another approach is to use logit analysis. Tybout and Hauser (1981) measured mode preferences directly. Then, using factor analysis on a set of responses to questions about the applicability of attributes to different modes, they developed perception measurements on three factors (Quickness and Convenience,

Ease of Travel, and Psychological Comfort) for each person. With mode preference as the independent variable, they used a logit model to determine the appropriate weights for each perception. The weights represent the importance of each of the three factors for the entire study group. The limitation with this approach is the same as for the previous one. It does not allow for individual differences in importance ratings.

Another approach to dealing with multiple attributes is multi-dimensional scaling (MDS) analysis. The data collected for this technique are not related to any particular mode. Respondents are asked to rate attributes by themselves. For instance, Dobson and Kehoe (1974) asked respondents to indicate how similar an attribute was to a set of other attributes. Dobson, Golob, and Gustafson (1974) obtained measures of importance of attributes to the respondents. In both cases, MDS was used to determine similarities among attributes and similarities among respondents. The mathematics are beyond the scope of this report. The important aspect of MDS is that it can be used to find groups of people that have similar ways of judging attributes. By segmenting the markets using this method and developing separate mode choice models for each segment, planners can account for individual differences effectively.

Two other techniques for multi-attribute model development measure attitudes toward several attributes at once. As discussed earlier in this paper, conjoint measurement is a technique that asks people to make an evaluative comparison between two alternatives defined by the same attributes at different levels. By asking respondents to make several such comparisons, the relative trade-offs of each attribute can be determined simultaneously or conjointly. Levin (1979) discusses some of the drawbacks to conjoint measurement that are overcome by using "information integration theory." The theory assumes that each attribute within a given system or set of attributes represents a piece of information to be integrated into the overall evaluation of that system. The functional form is an open

question. Typically, a respondent is asked to make a subjective evaluation of a combination of attributes ("How attractive would a commute trip costing $2.50, taking 35 minutes, and involving no transfers be?") By asking for several such judgments, the relative importance of each variable can be determined.

Additivity In Multi-attribute Models. The important aspect of the information integration approach is that the functional form can vary. It does not have to assume that the judgment is based on some linear combination of the judgments of the attributes. Some research has shown that the linear model is not adequate. For instance, Recker and Golob (1979) showed that if a mode is insufficiently attractive to a person on some particular attribute, it will not be chosen, no matter how attractive it is on other attributes. This has been labeled a *non-compensatory* model to distinguish it from a *compensatory* model, in which a sufficiently high evaluation on one attribute can **compensate** for a low evaluation on others. It has also been called a *multiplicative* model, as opposed to an *additive* model, because if the values of attributes are multiplied together and one value is zero, the values of the other attributes are irrelevant.

Evidence indicates that not all decision-making processes can be represented by a linear additive model. Louviere and Norman (1979) showed that a multiplicative model described subjective judgments of transit use much better than did an additive model. Bronner (1982) tested each kind of model in the choice between a train and a car. He found that train users seemed to follow a compensatory model, while auto users followed a non-compensatory model. For car users, if a mode did not satisfy a minimum level of privacy, independence, and time savings, it was not chosen, no matter how attractive it might be on other dimensions. Hensher (1982) used logit analysis to explore the functional form for various attributes relevant to the purchase of electric automobiles.

How Choice Affects Attitudes and Perception

Figure 1 and other earlier parts of this report suggested that mode choice can affect attitudes and perceptions as well as the other way around. An impressive body of research supports this finding. The direction of causation between attitudes and behavior has been the subject of research in psychology for many years. Recently, several research studies have investigated this issue with respect to mode choice specifically.

Tardiff (1977) used linear probability models to determine the direction of influence between attitudes and behavior. The results were not consistent with the hypothesis that attitudes cause behavior. In fact, the opposite was more strongly supported. Tischer and Phillips (1979) used cross-lagged correlational analysis of panel data to determine the relationships between beliefs and behavior. They analyzed data separately for SOV, carpool, and bus users. They found a strong, mutually causative relationship between the beliefs and behavior for SOV and bus users. The carpool data were not as clear because a strong promotional campaign for carpooling was put into effect that distorted the results. Reibstein, Lovelock, and Dobson (1980) found that behavior predicted beliefs much more strongly than the other way around, unless affect were introduced as an intervening variable. In that case behavior and beliefs were mutually causative. A recent review of attitudinal studies by Kroes and Sheldon (1986) summarizes several other studies that had similar findings.

Why does behavior so strongly influence beliefs? One answer is in cognitive dissonance theory (Festinger, 1957). Simply put, that theory holds that people change their beliefs to be in tune (consonant) with their behavior. A state of stress is induced when people are doing something contrary to what they believe in. Often, one of the simplest ways to reduce the stress is to change beliefs. The evidence is strong that this phenomenon takes place in people's perception of

transportation modes. Several studies have shown that people's perceptions are influenced by the choices they have made.

Lovelock (1975a) segmented respondents to a survey by frequency of transit use. He found significant differences in each segment's perception of all modes. Foerster, Young, and Gilbert (1977) found that transit and auto users have different perceptions about mode characteristics and that those perceptions change with experience. Golob, Horowitz, and Wachs (1979) compared auto and bus commuters' evaluations of each of the modes and found significant differences on most of the 25 attributes used in the study. All the differences supported the hypothesis that people evaluate their chosen mode most positively. Tybout and Hauser (1981) confirmed the feedback loop in their model, as illustrated in Figure 1. Choices did affect perceptions. In addition to the evidence that choices influence perceptions of attributes, Levin (1979) found that people place greatest importance on the attributes that support their mode choice.

Using Knowledge

Even though people's perceptions of mode attributes are affected by individual characteristics and by their behavior and experience, they are also determined to some extent by the actual attributes. If people are not exposed to information about the modes, they can not account for that knowledge. Little, if any, research has looked specifically into the question of how people seek out information in transportation mode choice. However, from research in other fields, it is clear that there are large individual differences in how it occurs. Some people are very thorough in seeking out all relevant information and others stop looking when one critical piece of information allows them to make up their minds. Some people are very open to new information and others distort it to fit preconceived ideas. The evidence in the previous parts of this section on cognitive process supports the fact that these observations apply as well to information on transportation mode choices.

Research has been conducted specifically on what people know about transit systems. Deslauriers (1975) made a strong case that bus stops are very important in encouraging transit ridership, since they come at the beginning of the chain of behaviors and reinforcers for riding the bus. However, bus stops are not the critical hole in people's knowledge of the transit system. Blankenship (1976) and Deslauriers (1978) showed that auto drivers tend to know where bus stops are, but they do not know much about other aspects of transit service, such as fares and frequency.

Blattberg and Stivers (1976) tested the efficacy of a program to provide transit maps to people in a specific transit corridor. The analysis showed an increase in off-peak ridership, but none for peak ridership. Tybout and Hauser (1981) tested the effectiveness of a bus information program on transit ridership. They found that, by providing more and better information, people's knowledge of the system increased and ridership did increase significantly. However, after the end of the information program, ridership dropped back to previous levels. The authors hypothesized that either (1) the program did not last long enough to change habits or (2) poor service undermined the repeat usage by people trying the service.

This research and research concerning the use of information generally indicate merely presenting information does not mean that it will be incorporated into the decision-making process. Furthermore, if the additional knowledge causes people to try some new behavior, that new behavior will not persist unless it satisfies other transportation requirements.

The Influence of Habit

Perhaps one of the best ways to summarize all the influences of cognitive process on mode choice is to recognize the importance of habit in transportation choices. Once people have made a choice, they have a tendency to reinforce that choice by changing attitudes and perceptions so that their beliefs support their choice. They also tend to emphasize the importance of the attributes that support

their choice. As a result, the processes they use to combine evaluations of attributes tend to stop short with those that are consistent with the choice they have made. In addition, they are not likely to seek out knowledge that would tend to change their choice. Parsons (1980) supports the importance of habit.

> Humans are not purely rational, as some economists (and others) presume, especially when people are developing, maintaining, or losing some habitual behavior, of which most behavior in transportation consists. (pp. 47-48)

Habitual patterns of travel develop over time. Hanson (1979) found regularity in occurrence of most trips, as well as regularity in trip chains. Kitamura and Van der Hoorn (1987) found that regularity in travel patterns held up strongly between two waves in a panel study. Pas (1988) identified multi-day as well as daily patterns that were repeated consistently. These kinds of regularities support habits in mode choice.

Lovelock's (1975b) proposed model of mode choice used the concept of "modal pool" to represent habit. The "modal pool" consists of the modes that people perceive to be available to them at any moment. It is affected by the choice that they have already made and the new information that they may acquire. Presumably, to be realistic, the "modal pool" is quite limited for most people. Banister (1978) proposed a four-stage model of mode choice, including

1. decision to acquire a car,
2. determination of car availability,
3. decision to use the car, and
4. allocation between modes by other household members.

He proposes to include satisfaction due to previous experience and habit as part of the third stage of the model. Gensch and Torres (1980) acknowledge the importance of habit in their segmentation of the transportation market. One segment was entitled "auto only," which meant that those in the segment so strongly favored auto use that it was impossible for them to switch. Kawakami and Hirobata

(1984), in their analysis of the response to new rail service, found that modal diversion was time-dependent. They explained this finding to be a result of the time necessary to break existing habits.

The importance of habit should not be over-emphasized. People do change. For instance, in Blankenship's (1976) survey of Orange County, California, auto commuters, he found that 52 percent of those who used autos out of habit said that they could switch to transit. In a study of potential carpoolers, Horowitz and Sheth (1977) found that a large proportion of auto drivers have a neutral attitude toward ridesharing and could be swayed to shift. Goodwin, Dix, and Layzell (1987) have used several different approaches to studying habit formation and habit breaking in transportation decisions. Especially through the use of panel data, they have been able to develop insights into the effects of turnover and renewal on habit formation. They emphasize the importance of "life shocks" on changing habits. These are specific events, such as moving, changing jobs, having children, etc., that make long-standing habits fit less and less well with their life environment. Their research accounts for the fact that habit is a strong determinant of mode choice until some change occurs.

Summary

Understanding how people process information is critical in studying mode choice and in designing and promoting alternative transportation modes. People cannot be assumed to gather all relevant information, perceive it accurately, weigh it evenly when they combine it, and act without prejudice on the outcome of this evaluation. They do not pay attention to all information. They distort information to fit with choices they have made. Once they make some choice, they have difficulty producing a change. Mode choice models that do not take these factors into account cannot represent the process accurately or realistically. Promotions that do not consider these processes will not be effective.

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