Classification of Approaches to Travel-Behavior Analysis

J.M. GOLOB, Ministry of Transport and Public Works, Netherlands, and THOMAS F. GOLOB, Bureau Goudappel Coffeng, Netherlands

This is intended to be a review of approaches to the analysis of travel behavior. We attempt to make it different from previous reviews by categorizing each approach discussed. Clearly, in reality such complex studies do not fit into a few rigid categories. Nevertheless, we have found the categorization to be useful in our own attempts to understand the similarities and differences among the known approaches. It serves to organize comparisons and might possibly help identify areas for further study.

The categorization is based on a cross-classification according to five subjects. They are (together with their simplified labels)

1. Activity-based approaches (Activities),
2. Approaches using subjective variables (Attitudes),
3. Approaches using population segmentations (Segmentations),
4. Approaches using controlled experiments (Experiments), and
5. Approaches directly involving choice models (Choices).

A full matrix cross-classification scheme is used (Figure 1). The rows of the matrix represent the primary subjects, and the columns represent the secondary subjects. The subsections of the paper are organized in the same order as the cells of the matrix. The only category of approaches not covered in this review is that for the mainstream of discrete-choice models that are now standard travel-behavior techniques.

A substantial number of references are cited in this review. This was the result of the desire for proper credit for different approaches and of the specific motivation associated with searches for missing links in the categorization scheme. However, another reason for including so many references is in response to a major conclusion of this review: researchers in the field of travel-behavior analysis are continuing to reinvent old concerns and approaches. The body of literature is building up dramatically without a corresponding increase in insight and analysis capability. This review is a modest attempt at compiling results in a way that might prove useful in continuing research.

Wherever possible, references from outside the field of transportation research were suppressed if a transportation research reference was found that conveyed the appropriate information. Consequently, this review is not a good place to look for background material from fields such as psychology, economics, geography, or marketing research. Also, wherever possible, citations were made to readily available sources, particularly journals; reports of research organizations were only included where no corresponding journal article could be located.

Finally, discussions of methodology and data collection were minimized. These subjects are perceived to be covered in other, complementary reviews.

ACTIVITIES

Activity approaches have been emerging in recent years as a challenge to the orthodoxy of the established travel-demand modeling techniques. The proponents of activity research have discussed extensively the weaknesses and limitations of current disaggregate demand models. They have advocated the replacement of trips by better measures of activity patterns. This is considered to be central to predictions based on an understanding of the underlying causes of travel behavior (1-3).

The approaches adopted vary enormously. Nevertheless, they can be characterized as concentrating on the types of things people do outside and inside their homes in the setting of their physical and social environment. The most ambitious goal of these approaches is the understanding of what has been termed complex travel behavior. This requires an understanding not only of individual behavior,

Figure 1. Matrix cross-classification scheme.

PRIMARY FOCUS	SECONDARY FOCUS: ACTIVITIES	ATTITUDES	SEGMENTATIONS	EXPERIMENTS	CHOICES
ACTIVITIES	1.1	1.2	1.3	1.4	1.5
ATTITUDES	2.1	2.2	2.3	2.4	2.5
SEGMENTATIONS	3.1	3.2	3.3	3.4	3.5
EXPERIMENTS	4.1	4.2	4.3	4.4	4.5
CHOICES	5.1	5.2	5.3	5.4	

but also of household interactions as a means of explaining and predicting responses to a host of activity influences.

What the activity approaches lack in terms of cohesive theory is compensated for by a profusion of concepts and methods (and an accompanying profusion of new travel-behavior nomenclature). This reflects the diversity and interdisciplinary nature of the research. Overviews, with the exception of those by Root and others (4) and by Damm (5), tend to be partial rather than comprehensive. However, a good understanding of the extent of work in the field can be gained from these two sources and from studies by Damm (6), Jones and others (7), Wigan and Morris (8), Allaman (9), Pickup and Town (10), Carpenter and Jones (11), Morris (12), and Root and Recker (13).

The potential advantages of activity-based approaches would appear to be considerable. Intuitively, it seems appropriate that travel be viewed as arising out of activity needs and desires. For policy evaluation purposes, the approaches are attractive because of their suitability in considering policies in which effects might be indirect (for example, changes in working hours). Also, policy initiatives can be studied in terms of their influence on the extension, contraction, or substitution of activities. This goes beyond the evaluation of policies in terms of conventional economic costs and benefits.

Views appear to be divided with regard to the immediate applicability of the approaches. Those whose objectives are comprehensive activity-based demand models typically feel that there is still some work to be done before replacements can be offered for conventional models (5). Others have argued that despite the lack of a cohesive theory, elements within the activity framework can be used together with existing models and indeed should be used to adapt and improve them (14,15).

In stressing the importance of new or previously overlooked topics (such as spatial and temporal constraints on choices and influences of life cycle), activity approaches risk neglecting some of the traditional and still important explanators of travel behavior (12). Moreover, activity analyses often require extremely detailed data. Lack of these data has inhibited development. More attention might usefully be directed toward adapting existing data sets, and Knapp (16) offers an initial attempt at this. Also, activity approaches might be tested on limited data by relying on simulation and artificial sampling techniques to expand the data base; these issues have received little attention.

It is our premise that activity approaches can benefit in this early stage of development from systematic comparisons with other types of approaches. Such comparisons are attempted in this review.

Activities

Following the scheme the matrix described earlier (Figure 1), the travel-behavior studies in this category are those that deal with relationships among components of activities. In many cases, these studies have served as foundations for later developments that employ segmentation analyses, experimental methods, or choice modeling. In other cases, the studies are relatively independent of the efforts described in other sections of this review, but they do not fit into one of the categories that cross-classifies activity approaches with other subjects. These include approaches that use simulation techniques.

One of the most important features of activity-based approaches has been the explicit recognition of the joint constraints on travel behavior of time and space. Foundations for this concept were provided by Hägerstrand and his colleagues, who greatly advanced the field known as time-space geography, or simply time geography (17). Time-space geography offered a unified paradigm for the study of complex travel behavior. The paradigm complemented the perspective on activities as satisfactions of human needs and desires provided by Chapin (18,19) and his colleagues. Thus, researchers by the early 1970s had comprehensive constructs on which to formulate and test hypotheses of activity behavior.

Activity studies based on simulation models were the first to emerge. Early efforts were those of Nystuen (20), Brail (21), Ginn (22), and Hemmens (23). Nystuen related the structure of shopping tours (round trips from home and back) to spatial factors by using stochastic processes, whereas Ginn employed dynamic programming methods in a seminal study of spatial influences on multiple-stop tours (often called trip chaining). Hemmens related trip-chaining events to household socioeconomic characteristics by using a Markov model.

The foundations provided by Hägerstrand and Chapin began to appear in a second group of simulation models by Tomlinson and others (24), Westelius (25), and Vidakovic (26,27). Tomlinson developed an entropy-maximizing model that allocated urban area population to the most probable spatial activity location for successive time periods. This approach has been further developed by Vidakovic within a choice framework. The work of Westelius (25) and Vidakovic (26) continued earlier investigations concerning the lengths and number of stops on a tour by using stochastic simulations and probability distributions, respectively. Vidakovic (27) represents an early attempt at placing trip-chaining phenomena in a broad behavioral context.

Direct applications of the concepts advanced by Hägerstrand and Chapin are to be found in the next group of studies. Concepts from the latter source were operationalized by Kobayashi (28,29) in a queueing model that maximized a cost-effectiveness function to estimate the distribution of trips in the satisfaction of activities. The model dealt specifically with relationships between the number of tours and the number of stops on the tours under various conditions. Building directly on the paradigm provided by the time geographers, Lenntorp (30) developed a simulation model that computed the potential number of time-space paths that an individual could follow in executing a particular activity program. This model was used for exploring the implications of transport network and land use changes, but it has no predictive capability. Going a step further, Burns (31) used these constructs in a theoretical study that traced the effects on accessibility of possible policies affecting spatial and temporal constraints on travel. In the latest and most advanced work in this area, Kitamura and others (32) and Kostyniuk and Kitamura (33) combined a theoretical model with regressions and contingency-table analyses to investigate the properties of time-space paths as reflected in trip-chaining behavior.

Considerable insight into activity behavior has also been gained by using more descriptive analysis techniques. Cullen and Godson (34,35) conducted a series of multivariate statistical analyses aimed at identifying salient features of activity patterns (which included subjective variables). Bentley and others (36) fitted probability distributions in studying frequencies of return trips to home by tour (or journey) stages, whereas Shapcott and Wilson (37) were able to infer trade-offs made in time al-

locations by comparing observed correlations among activities with theoretical correlations that would result from certain types of behavior. Oster (38,39) and Hanson (40) identified important behavioral implications by isolating trip-chaining effects related to the work trip. (Hanson, in a study apparently performed independent of the related earlier efforts by Cullen and Godson, employed an effective statistical-analysis technique by using data on linkages among activities, which is related to the focus of some of the analyses discussed in later sections of this paper.)

Descriptive analyses were also included in the extensive study reported by Jones and others (41), which also involved further developments of a method of the type discussed later. These analyses appear to have led to the formulation of a combinatorial algorithm to generate the feasible responses that an individual could adopt for rescheduling activities when faced with a change affecting existing activity patterns. The algorithm is based on heuristic rules to reduce the number of potential permutations and has been used in the generation of choice sets (42).

Further descriptive statistical analyses have been performed by Adiv (43), Godard (44), Herz (45), Kitamura (32), and others. These studies are particularly important in that they demonstrate how readily available statistical techniques can be used to identify salient features of activity patterns from data sets collected in support of conventional trip-based travel-demand models.

Activities/Attitudes

In this section we are concerned with approaches that relate activities to attitudes and other subjective variables. Much of the conceptual work along these lines can be traced to that of Chapin (19,46), in which relationships were examined between needs and the creation of activity patterns. This work focuses on role structure, which was defined as a combination of sex, family responsibilities, and employment status. The work contrasts with that of the time-space geographers (reviewed in the previous section) in that it deals with preferences rather than constraints (47).

Kutter (48-50) has integrated the concept of roles with time and space constraints and has recommended using segmentation methods to investigate relationships between activity patterns and a variety of socioeconomic variables aimed at depicting role structures. By using a related but more sociological approach, Fried, Havens, and Thall (51) developed a conceptual model of travel choice based on adaptation processes. This model incorporates a number of subjective variables, particularly role indicators, and several of the model hypotheses were tested by Allaman and others (52). Also, Cullen and Godson (34,35) and Stephens (53) included subjective measures of commitment to activities (measurements of the degree to which an activity is compulsory versus discretionary) in their empirical work on activity structure.

There appears to be very little recent work focusing on perceptions and beliefs about activities. An exception is the situational approach reviewed later, which attempts to account for a variety of factors affecting activity choices through the use of interactive surveys and segmentation concepts. Among the factors demonstrated to restrict activity choices are prejudice and familiarity (54). In addition, experimental approaches involving gaming simulations have been developed for exploring subjective influences on activity patterns, and these methods are reviewed in the section Activities/Experiments.

Activities/Segmentations

Three types of approaches appear to fall within this category. The first type involves the use of segmentations based on household socioeconomic and demographic characteristics. Chapin (19) and his colleagues pioneered the use of such segmentations in understanding differences in activity patterns. In particular, Chapin proposed the use of stage in the family life cycle (now usually called simply life cycle), which incorporates marital status, the number and age distribution of any children, and whether children live at home. This concept has been used effectively in a number of travel-behavior studies. In the realm of activity analyses, it was developed by Reichman (55) and has been employed extensively by Jones and others (7) and Allaman and others (56). Examples of the use of other important segmentation bases for specific analyses of differences in activity patterns are found in studies by Hanson (57) (age) and by Hanson and Hanson (58) (sex).

The second type of segmentation involves using activity patterns themselves as the segmentation basis. Recker and others (59,60) and Pas (61,62) have shown that the myriad of daily activity patterns typically reported in a sample of activity diaries can be grouped into a relatively small number of categories (10 or less) without significant loss of statistical information. This represents a population segmentation as well as one of activity patterns, because an individual and a household are associated with each pattern.

In the approach of Recker and others the homogeneous groups of activity patterns are determined by using pattern-recognition techniques. They are later employed in an activity-pattern choice model. In the approach of Pas (61,62), the groups are found by using multivariate statistical methods like those commonly used in population segmentation. An investigation was then conducted in which differences among the activity-pattern groups were described in terms of the socioeconomic characteristics of the household segments. This appears to be a particularly effective approach to exploratory activity analyses, which could be extended and applied in different situations.

Finally, a third type of segmentation approach underlies the simulation model developed by Zahavi and others (63-65). This model interrelates household travel by various modes with residential location, car ownership, and transportation systems supply. It takes advantage of certain regularities found in the distribution of travel expenditures by household segments. Both time and money expeditures are included (66,67).

Segmentation structure in the context of aggregate activity patterns is a key to the Zahavi model, because expenditure distributions have been demonstrated to be stable over time and across cities only for segments defined on the basis of certain household characteristics. Moreover, the segmentation structure is dynamic; households are reassigned among segments in the course of the simulation as conditions change and feedback occurs. As with a few other analysis approaches reviewed earlier, the model uses total travel distance in place of trips as a measure of total activity satisfaction. Such an aggregate measure is consistent with the intended application of the model in forecasting changes in total intraurban travel and population distributions. An important issue for future research is to compare the performance of this model with alternative forecasting techniques based on more conventional definitions and assumptions.

Activities/Experiments

In this section we are concerned with experimental methods for studying the relationship between activities and travel patterns and for exploring and estimating responses to policy affecting the location and scheduling of activities.

The use of gaming as an experimental technique for investigating decisionmaking has been proposed and tested by Hoinville (68), Biel (69), and Burnett (70). Previously, Chapin (18,19) had reviewed gaming simulation techniques in the context of activities and travel.

The best-known example of such games is the Household Activity Travel Simulator (HATS) (71). This is an interactive device that uses visual-display boards in in-depth group-interview situations. With previously recorded personal activity data, each household member is asked to construct his or her activity pattern on the board by using colored blocks for time periods that represent the 24-h day. Locations of activities are also recorded and marked on maps on the upper section of the board. Respondents are then presented with a change in the level of public transport services or some other aspect of the environment and are asked to rearrange their activity schedules. Discussions are encouraged between household members and with the interviewer to test out feasible options and to reach decisions as to which alternative they would adopt.

The technique allows the study of constraints and adaptive strategies and their likely effects on travel patterns. Also, through the use of group interviews, interpersonal linkages can be fully explored. This is most useful for small-scale exploratory studies. Among the applications reported are evaluations of changing school hours and changing levels of public transport services in rural and urban areas (7,72). A similar gaming technique (called REACT) has been applied to the investigation of energy restrictions on travel by Phifer, Neveu, and Hartgen (73).

Extended possibilities for structuring such interactive gaming techniques have been proposed by Brög, Heuwinkel, and Neumann (54). Many of these possibilities have direct application in the situational approach discussed in the section Segmentations/Activities, but others are relevant to a broader set of applications. In addition, Burnett and Hanson (74) used a variation of previous gaming techniques to explore spatial choice behavior in the context of constraints. This work is partly related to the concepts of mental maps and learning theory reviewed in the section Attitudes/Activities.

Activities/Choices

Travel-behavior analyses that focus on choices among alternative activity patterns have begun to emerge in the last five years or so, building on the foundations provided by the studies reviewed so far. In general, these analyses appear to have as a long-range goal the development of travel-demand forecasting techniques that would replace conventional trip-based techniques. A complementary set of analyses, reviewed in the section Choices/Activities, appears to be aimed at incorporating activity-pattern components in conventional forecasting techniques.

The initial efforts in this category focused on choice of activity duration. Bain (75) used an econometric approach to structure individuals' choices of out-of-home activity durations but did not account for interactions among activity sequences. Such interactions were subsequently addressed in a simultaneous equation model developed by Jacobson (76). In this model, a two-stage choice process was defined that involved choice of activity duration followed by choice of travel pattern. Importantly, household interactions were considered. Later, Allaman and others (52) formulated a constrained simultaneous equation system that attempted to capture allocation of time among many different activities for life-cycle segments. This represents an important application of life-cycle segmentation, but difficulties were encountered in explaining choices of activity duration.

Damm (77,78) and Damm and Lerman (79) developed a model that described the joint choice of whether to participate in an activity and the duration of the activity. Choice models were estimated for activities in five daily time periods defined around the work trip and for various population segments. In each model, variables were constructed to capture interactions with choice in previous time periods. The results were found to be consistent with the concept of discretionary and compulsory activities and with expected strong relationships between household characteristics and activities involving trips to and from home.

A different approach was pursued by Van der Hoorn (80,81). Choice models were specified for activity type and location; location was confined to home, in town, or out of town. By using population segmentations of the type reviewed in the section Choices/Segmentations, populations were then assigned to the three locations by quarter-hour time periods based on the results of the choice model estimations. This extends the simulation approach developed by Tomlinson and others (24) into the realm of choice. It is reported that the Van der Hoorn model is being used to explore the impacts of policies involving variable working hours, income reduction, and reduction in working hours according to various schemes.

A new type of trip-generation model was developed by Landau, Prashkar, and Kirsh (82) in which many of the same concepts of household interactions and compulsory versus discretionary activities were taken into account. A multistage choice process was specified. It involved the choice as to whether or not to engage in a specific activity, the conditional choice of executing a chosen activity during a specific time period, and the conditional choice as to the specific household member who would make the trip.

Possibly the most ambitious choice-modeling study in the field of activity analyses is that of McNally and Recker (83). A five-stage simulation model has been developed to model directly the choice of complex activity patterns. The stages are (a) specification of activity programs for each household member, considered within the context of heuristic rules concerning interactions and constraints; (b) generation of a full set of feasible activity patterns to meet these programs; (c) reduction of the set of feasible activity patterns by eliminating inferior patterns with a multiobjective programming algorithm; (d) specification of a representative set of activity pattern alternatives by using pattern recognition and classification techniques; and (e) a choice model of the usual travel-behavior type with the representative patterns as choice alternatives. The theoretical underpinnings of this simulation model [discussed by Root and Recker (84)] are related to the utility theory models proposed by Burns (85) and by Golob and others (86). These models focus on travel distance and the roles of choice constraints. The fourth-stage algorithm is founded on the segmentation approach discussed earlier.

Finally, it appears that some of the ongoing studies that have been reviewed might soon evolve

into choice models of one type or another. For example, Vidaković (87) reports progress toward a choice model system employing the concept of disposable time intervals for structuring choice probabilities for the execution of discretionary activities. Likewise, Beckmann, Golob, and Zahavi (88) document a conceptual approach aimed at linking spatial distributions of populations and activity sites with activity patterns. Many other types of approaches can be expected in this particularly fruitful research area.

ATTITUDES

In this section, we cover travel-behavior analyses that focus on subjective variables such as perceptions, evaluations, and judgments. In transportation research, these subjective variables are generally referred to as attitudes. In keeping with the theme of this review, an attempt is made here to relate analyses dealing with attitudes to other types of analyses, namely, those dealing with activities, segmentations, simulations, and choices. In this way this review is meant to differ from previous ones. Many such reviews are available: those by Hartgen (89), Golob (90), Golob and Dobson (91), McFadgen (92), McLeod (93), Michaels (94), Spear (95), Hensher and McLeod (96), Hartgen (97), Levin (98), Louviere (99), Louviere and others (100), Dix (101), Held (102), Michon and Benwell (103), Tischer (104), Johnson (105), Stearns (106), and Dobson (107).

This review fails to consider in any detail the theoretical bases for attitude measurements and modeling. These bases are found primarily in psychology and have been covered in reviews such as those of Golob (90), Michaels (94), Johnson (105), Levin (98), and Held (102). Nor does this review deal with details of methodology and data collection. These issues are also covered in comprehensive fashion in previous reviews, such as those of Golob and Dobson (91), Dobson (107), Spear (95), Louviere and others (100), and Tischer (104). These reviews contain numerous references to prior applications of many techniques in marketing research.

Semantic confusion has accompanied application of attitude measurement and modeling in transportation research. Levin (98) observed that there are almost as many definitions of attitudes as there are researchers working in the field. Four contemporary reviews [those by Held (102), Levin (108), Michaels and Allaman (109), and Michon and Benwell (103)] specified four incompatible sets of definitions for subjective variables. This review attempts to avoid nomenclature problems by simply ignoring distinctions among types of subjective variables except where such distinctions are necessary to distinguish alternative research approaches. Where distinctions are necessary, we adopt the rather arbitrary but useful separation of subjective variables into perceptions, beliefs (including satisfactions and preferences), and behavioral intentions.

Attitudes/Activities

It is useful to classify in this category studies that have been concerned with individuals' perceptions of the space around them. These perceptions and associated beliefs can be regarded as attitudes about the opportunities and constraints affecting activity patterns.

Early efforts appear to have been directed in four ways: (a) development of the concept of mental maps; (b) scaling of spatial preference functions; (c) specific perceptions of travel distance, time, and cost; and (d) application of learning theory to spatial cognition. First, mental maps attempt to capture individuals' perceptions of spatial opportunities within a given geographical area. Gould and White (110) and Morris (111) demonstrated that such perceptions depend on familiarity as measured by proximity of residence to the area in question, length of time at residence, visits previously made to the area, and certain socioeconomic and demographic characteristics. Horton and Reynolds (112) demonstrated how such a concept could be used in travel-behavior analyses. MacKay and others (113) and Young and Richardson (114) used mental-map principles in models of spatial choice behavior. Young and Richardson used the method of trend surface analysis (115) to quantify spatial perceptions.

Spatial preference functions have been studied by Rushton (116,117) by using multidimensional scaling methods of the type used in several nonspatial studies. This work serves as a foundation for more direct applications to travel-behavior analysis, but follow-up studies have not emerged. Only a few studies, such as that by Koppelmen and others (118), have taken up the objective of determining spatial preference structures, but these studies have been largely independent of the original work by Rushton.

Distance perceptions have been studied by Golledge and others (119), Briggs (120), Canter (121), and others and time perceptions by Young (122), Young and Morris (123), Clark (124), and others. In addition, Lansing and Hendricks (125), O'Farrel and Markham (126), Dix and Goodwin (127), Henley and others (128), Adiv (129), and Brög (130) studied drivers' perceptions of car costs. These studies provide psychophysical foundations for transformations of variables in conventional travel-demand models. In particular, they demonstrate that perceived and objectively measured variables differ systematically, and the relationships are not generally linear. Unfortunately, very few demand modelers appear to be aware of such results (109).

Finally, learning theory has been applied to spatial perceptions by Golledge and Brown (131), Golledge (132), and Burnett (133,134). Typically, these studies combined learning theory with psychometric scaling of perceptions and demonstrated how stereotypes can be formulated depicting individuals' evolving activity patterns (135). They demonstrated how multiple-activity patterns could be chosen by the same person over time.

More recently, Swiderski (136) developed a model of destination choice that incorporated concepts of mental maps and learning theory. However, the approach is limited by the simplistic assumptions required in Markov process models (135). Finally, Burnett (137) proposed measuring spatial perceptions in terms of both the physical and the social environment; the social environment might include components of territoriality, desires for interactions with friends, or favorite locations.

Associated attitudinal issues are discussed in the section Activities/Segmentations, which concerns segmentations related to household roles and responsibilities and perceptions of constraints on choice. Related issues are also discussed in the section Segmentations/Activities, which concerns segmentations based on perceptions of time, costs, and environmental constraints.

Apparently there have been no applications to activity-pattern choice of full-blown attitude-behavior models of the type reviewed in the section Choices/Attitudes. Given the development of methods to identify typical feasible patterns, this might be an area for fruitful research, particularly in light of observations by psychological theorists that attitudes correlate well with a complex of related

behavior but not with a single choice event alone (138).

Attitudes

No studies have been classified in this category. For the purposes of this review, studies dealing primarily with attitude structure are not interesting unless such structure is related to one of the other subject areas represented in Figure 1.

Attitudes/Segmentations

A number of studies have compared attitudes among population segments. Some of these were concerned with attitudes about proposed hypothetical transportation systems; they will be discussed in the section Segmentations/Experiments. Other studies involved attitudes on a segmentation basis as well; they are discussed in the section Segmentations/Attitudes. The remaining studies comparing attitudes among population segments are the subject of this section.

The most important of the attitude-comparison studies are deemed to be those that investigated differences between users and nonusers of particular travel modes. They are important because evidence was uncovered that was later used in improving attitude-behavior models. Also, the results might have an impact on certain types of sampling techniques used in disaggregate demand models.

Comparisons of perceptions and preferences between users and nonusers were conducted by Gustafson and Navin (139), Lovelock (140), Byrd (141), and Dobson and Tischer (142), among others. Significant differences were noted. In particular, Dobson and Tischer observed that, in general, individuals who use a mode view that mode more favorably than those who do not. This might be the consequence of any of several behavioral processes; Horowitz (143), Golob and others (144), and Tischer and Phillips (145) all tested one particular hypothesis. This was that individuals with choices tend to upgrade their feeling about their chosen alternative and downgrade those about the rejected ones after a choice has been made. Results of these tests were positive and have been elaborated by further studies. Furthermore, such a hypothesis is consistent with psychological theories such as cognitive dissonance (146) and self-perception (147), both of which are related to the common notion of rationalization. These studies demonstrate the effective use of segmentation to test travel-behavior hypotheses.

Attitudes/Experiments

In this section, studies are discussed that measure attitudes toward proposed new transportation modes or other hypothetical situations by using the simplest types of experiments. These experiments involve the presentation to respondents of attributes of the hypothetical situations. The attributes are presented singly or in pairwise combinations, and reactions are assessed by using various survey-scaling devices. (Surveys of this type are usually accomplished through mail-back or home-interview questionnaires.) Travel-behavior analyses in which experimental designs are more closely linked to the analysis method itself are the subjects of the section Experiments/Attitudes. (In the terminology of conjoint measurement, this section deals with two-factor-at-a-time approaches and with simple disjoint measurements; in a later section, full-profile approaches will be discussed.)

An early approach is that of Golob and others (148). Thurstone's model of comparative judgment was used to estimate scale values for various attributes of dial-a-ride services based on survey paired-comparison judgments. Unidimensional semantic differential scales were also analyzed. The effort led to useful insights into consumer preferences, but the methodology has since been supplanted by more powerful multivariate measurement approaches [for example, that of Gensch and Golob (149), where comparisons were made among preference structures regarding different types of proposed new modes]. Benjamin and Sen (150) demonstrated how multivariate approaches can lead to improved insights when compared to unidimensional scales.

A two-factor-at-a-time conjoint-measurement approach that has seen application in transportation research is trade-off analysis. It was developed by Johnson (151) and involves respondent's rankings of combinations of the levels of two attributes. The rankings are repeated for different pairwise combinations, and the values or utility weights for the levels of each attribute are estimated from the ranking data for a sample of respondents by using a special scaling algorithm. The use of the approach in travel-behavior analysis is described by Ross (152) and by Donnelly and others (153). It has been successfully applied in assessing the impacts of public transit fare changes (154), in assessing public opinions about public transit operating-assistance programs (155), in establishing preferences for rural transit services (156), and in forecasting the effects of proposed changes in work schedules (157). In this last study, a before-and-after survey showed that the approach based on "before" data produced aggregate predictions that coincided well with actual behavior but that specific attribute utility weight estimates were less adequately reproduced. Such a before-and-after test is called for in evaluating other approaches as well.

Attitudes/Choices

One of the major objectives of attitudinal studies in travel-behavior research has been to explain travel choices in terms of subjective variables. If a strong link were to be found, predictions could be made in transportation planning and marketing regarding the effects of decisions influencing such things as travel comfort, convenience, safety, or even style. This objective has been sufficient to motivate a continuous stream of research for the last 25 years or so.

Early studies aimed at linking attitudes and travel choice can be divided into two types based on model specification: those in which the explanatory variables consisted entirely or almost entirely of subjective variables and those in which the explanatory variables consisted of objectively measured travel times and costs together with one or more subjective variables. Both types of early studies predominantly focused on choice of mode, usually for the home-to-work trip, which was consistent with contemporary studies on other topics in travel-behavior research.

The former type of early study typically used as explanatory variables individuals' ratings of their perceived alternative choices on a series of semantic differential scales. These ratings were designed to capture satisfactions or other perceptions and beliefs concerning modal characteristics. Statistical correlations between the explanatory variables and a dependent choice variable were then estimated by using the disaggregate demand model methodologies fashionable at the time. The approaches were largely based on developments in psychology and marketing research. Important among these early studies are those by Sommers (158);

Golob (159); Hartgen and Tanner (160,161); Allen and Isserman (162); Demetsky and Hoel (163); Wallace and Sherret (164); Ewing (165); and Hensher, McLeod, and Stanley (166). Hartgen (167) and Westin and Watson (168) provided comparisons of explanatory power between models based on attitude and objective variables, with mixed results.

There is disagreement among reviewers concerning the overall success of these studies. It is safe to say that results depended on the specific nature of the choice situation and the techniques used for data collection and analysis. Success was pervasive enough to encourage refinements of the approach. Thomas (169), Dobson and Tischer (170), and Hensher and McLeod (96) introduced different types of subjective variables; Recker and Golob (171) and Recker and Stevens (172) introduced choice constraints. Models were also extended to other choice situations: Cadwallader (173) and McKay and others (174) studied spatial choice; Costantino, Golob, and Stopher (175) studied choice among hypothetical new transport modes. Generally, the links found between attitudes and travel choices were stronger than in previous studies. This was encouraging (159,176), but many questions remained unanswered.

The second type of early attitude-choice study was concerned with the introduction of one or a few subjective variables in models based on time and cost variables. As noted by Dix (101), these studies were aimed at accounting for biases in travel choice not explained by time and cost variables (177-179). Efforts were focused on methods to capture a complex of subjective variables in a single index that could be included in conventional models. The subjects were comfort (180), convenience (181), reliability (182), and these three factors taken together (183). The methods generally used techniques of multidimensional scaling developed in psychometrics and applied previously in marketing research. Although considerable insight was gained concerning how travelers' beliefs and perceptions on these subjects are influenced by specific characteristics of travel modes, the methods have proved to be rather complicated and expensive to apply in practice.

Second-generation studies of links between attitudes and choices can be distinguished by the abandonment of the assumption of one-way causality. These studies recognize that attitudes can influence choice, but choice in turn can influence attitudes. The effect of choice on attitudes was first detected in the segmentation studies discussed earlier. There is strong support for the concept in psychological theories. Moreover, transportation researchers have proposed that feedback from choice behavior to attitudes might result from ex post facto rationalizations motivated by a questionnaire (184) or from habit formulation (185,186). [Voltenauer (187) goes so far as to contend that the direction of causality is essentially only from behavior to attitudes, a minority view among researchers.]

Empirical evidence supporting two-way causality between attitudes and travel-choice behavior has been supplied by Foerster and others (187a), Tardiff (184), Dobson and others (188), Horowitz (143), Dumas and Dobson (189), Golob and others (144), Tischer and Phillips (190), Reibstein and others (191), and Kroes (192). Foerster and others and Tischer and Phillips (190) based their conclusions of attitude-choice interdependency on longitudinal analyses of survey data at two points in time. Horowitz and Golob and others tested hypotheses of cognitive dissonance through reanalyses of four separate attitudinal surveys. Tardiff (184), Dobson and others (188), Reibstein and others (191), and Kroes estimated parameters in simultaneous-equation systems by using standard econometric methods.

The simultaneous-equation systems used in analyzing causality provide convenient structures for flow diagrams depicting the roles of subjective and objective variables in behavioral processes. As noted by Dobson and others (188), for every simultaneous-equation system there exists a flow diagram that unambiguously shows the linkages among the exogenous and the dependent variables. Such diagrams have been used by Dobson and others, Golob and others (144), Young and Richardson (114), Kroes (192), Levin (108), and others to contrast alternative modeling approaches. (However, not all recent attitude-behavior depictions subscribe to the generally accepted causal link from choice to attitudes). It is quite possible that further contrast of approaches using both simultaneous equations and flow diagrams would serve to resolve cosmetic differences and identify fruitful areas for further research.

The state of the art with regard to our understanding of attitude/choice relationships, although still imperfect, nevertheless has certain clear applications. In particular these techniques are potentially useful for examining the possible effectiveness of certain policy instruments and/or strategies for achieving certain transport policy objectives. In instances in which it is considered desirable to change or influence existing habits or travel patterns, such studies can help to indicate the methods most likely to bring about the desired effect. These methods may not, given the complex relationship between attitude and behavior, always be the most obvious or the most direct. An example offered by Kroes (192) is that of trying to increase train use at the expense of car use. It is suggested that changing the objective parking situation by limiting parking space or increasing charges is likely to be more effective than seeking to improve traveler satisfaction with the quality of train travel. Other likely policy applications could be studies on increased use of park-and-ride stations, the adoption of energy-saving driving habits, the use of seatbelts, and mode changes.

SEGMENTATIONS

In this section, analyses that focus on population or consumer segmentation are covered. Here it is assumed that segmentation refers to any systematic classification of population relevant to analyses of travel behavior and values. As in the case of attitudes, an attempt is made to avoid semantic problems by using simple nomenclature. Readers interested in such problems are referred to the review by Tye (193), in which the issue of market versus consumer segmentation is addressed. Additional, comprehensive overviews of segmentation approaches in travel-behavior research are provided by Reed (194), Lovelock (195), Hensher (196,197), Louviere and others (198), and Dobson (199).

As is generally the case in this review, this discussion does not concentrate on foundations for segmentation analyses that are outside the field of transportation research. These foundations are generally traced to previous applications of segmentation analyses in marketing research. They are discussed in previous reviews, particularly that by Dobson (199).

Segmentations/Activities

The major approach classified within this category stands somewhat alone. This situational approach has been described by Brög (200,201), and the interactive interviewing methods that support it have been explained by Brög and Erl (202).

The approach begins with the identification in detail of the decisionmaking situation of each individual, including his or her activity patterns. The potential for the individual to change behavior given an alteration in external conditions is then examined. The framework of the analysis is the identification of constraints that will rule out certain courses of action. These procedures allow the segmentation of individuals into groups with and without the potential to change their behavior. Constraints on actions are very broadly considered and may include lack of information as well as negative attitudes toward possible options. Individuals are further segmented by the nature of their potential responses, which may include nontravel responses. Through these selective means, small behaviorally homogenous groups are identified. These form the base on which forecasts are made of likely responses to policy changes.

The approach has been applied to a variety of policy questions. These include estimating reactions to public transit fare increases (203), investigation of the long-distance travel market and its further development in Germany (204), the acceptance of policies to encourage bicycle travel (205), and the testing of alternative rapid-transit scenarios (15).

The situational approach is data intensive and requires the use of skilled interviewers and trained analysts. This is an example of a method that requires specially collected data. There do not appear to be any examples of such data being reused to test policies not included in the original survey design. Nevertheless, the approach is unique and an important research topic would be to test it against several of the approaches discussed in the sections Activities/Segmentations and Activities/Choices and the approach proposed in the section Experiments/Activities.

Segmentations/Attitudes

Classified here are travel-behavior analyses that employ attitudinal segmentation bases. The usual objective of these analyses is a better understanding of how the underlying dimensions of perceptions and beliefs differ among population segments. The usual approach is to determine segments with homogeneous profiles of subjective variables, to assess the nature of the differences among the profiles, and to relate the segmentations to socioeconomic and travel pattern characteristics. Golob and Dobson (91) were early advocates of such approaches, and the theme was subsequently taken up in several of the overviews cited in the introduction to the sections on segmentations.

Many of the initial studies along these lines were concerned with understanding the underlying dimensions of perceptions and beliefs about proposed new transportation modes. These studies are reviewed in the section Segmentations/Experiments because they involve responses to hypothetical situations. Some of the methods used in these initial studies are compared by Nicolaidis and Dobson (206). The approaches were extended into the realm of attitudes about existing modes by Neveu, Koppelman, and Stopher (183), among others, and attitudes about destination-choice alternative by Stopher (207).

A negative note was interjected by Nicolaidis and others (208), who found that subjective variables in general performed poorly as segmentation bases when compared with other types of variables. These results were supportive of the approaches reviewed under Segmentations/Choices, which used perceptions of constraints on choice as segmentation bases. They also motivated Golob and Recker (176) to propose an analysis procedure for attitudinal data based on segmentations by perceived choice constraints (but which failed to account for causal feedback from behavior to attitudes). A further negative note is associated with the analyses of data based on respondents' similarity judgments. Such data uses have been shown to be susceptible to methodological problems (209,210) and data-collection biases (211).

Refined approaches have led to useful insights: Dobson and Tischer (212) found strong and interpretable relationships between choices and segmentations based on beliefs about modes, as did Gensch and Torres (213) in a segmentation study aimed more at target markets for public transit. Stopher and Ergün (214) found interpretable differences among attitudes related to attributes of recreational activities. Benjamin and Sen (215) demonstrated how segmentation based on multidimensional scaling of subjective variables can be used to identify specific transit improvements, and Tardiff (216) developed a comprehensive segmentation approach based on general attitudes toward car, public transit, and public transit improvements.

Another subject area for potential applications of attitudinal segmentations is that of roles and their relationships to travel behavior. The definitions of roles proposed by Fried (217), Koppelman and others (218), Havens (219), and others involve subjective variables as well as objective variables of the types discussed in the next section. Similarly, life-style has many subjectively measurable components when taken in its full meaning in marketing research. Segmentations based on psychographic variables might be useful first steps in addressing role, life-style, and personality in the travel-behavior context, and some progress has been reported here by Davis (220).

Finally, one segmentation concept from marketing research that has seen little apparent application to travel-behavior analyses is benefit segmentation (221). This refers to segmentations based on the benefits people are seeking in consuming a product or service. It is related to the notion of valence in psychology (222). The concept has been partly adapted in one approach discussed in the section Experiments/Segmentations, but it might usefully be extended in a segmentation by benefits and disbenefits of transportation investments. In this way the extensive methodology of segmentation (including advanced techniques of psychometric scaling and multivariate statistical analyses) would be brought to bear on the difficult measurement problem of distinguishing effects among population groups. For purposes of the evaluation of transport policies, this could be seen as a supplement to the procedures more commonly adopted in social cost/benefit analysis.

Segmentations

In this section, studies concerning the general uses of segmentations in travel-behavior analyses and comparisons of alternative types of segmentation bases are discussed. Also discussed here are segmentation approaches that use socioeconomic and demographic variables as bases, including those that combine such variables in innovative ways.

Lovelock (140), Hensher (196), and Dobson (223) discuss the similarities and differences between uses of segmentation in transportation planning and management and uses in the general field of marketing. Topics include contrasts of the service-provision and profit-maximization motives of the two fields, respectively, and identification of situa-

tions where resolution of differences is possible. These are judged to be important discussions because of the potential for the application of results from extensive research efforts in marketing [for example, those by Johnson (224) and Kotler (225)] to problems in travel-behavior analyses. Rubin and others (226) document one such application.

For comparisons of alternative segmentation bases, Tye (193) listed six types of bases: (a) subjective judgments, (b) sociodemographics, (c) relevant choice sets, (d) attributes of choice, (e) use and observed choice, and (f) geography. Segmentation bases types b and f are discussed in this section.

An empirical comparison of segmentation bases representing each of the first four types was conducted by Nicolaidis and others (208). The bases were compared with respect to five criteria: measureability, substantiality (relative sizes of the population groups represented by the segments), statistical robustness of the results, relationship with planning of service options, and relationship with travel behavior. [Gensch and Torres (213) also used these five criteria in an evaluation of a segmentation approach reviewed earlier; a sixth criterion was introduced: accessibility to the segments for purposes of the marketing promotion of transportation services.] Nicolaidis and others (208) reported that segmentations based on choice constraints (relevant choice sets) performed best.

Segmentations based on socioeconomic and demographic variables have been common in travel-behavior analyses. These segmentations have evolved from the use of single variables [for example, focus on income effects by Stopher and Lavender (227)] to the use of complexes of variables. A particularly useful complex has been life-cycle. Segmentations based on life-cycle have been important for years in marketing research (228), and pioneering applications in transportation can be attributed to Aldana and others (229) and Chapin (19). More recently, the concept has been explored in the travel-behavior analyses of Bourgin and Godard (230), Stopher and Ergün (213), Downes (232), Allaman and others (56), Bourgin and Godard (233), Collin (234), Knapp (235), Salomon and Ben-Akiva (236), Wigan (237), and Zimmerman (238). Clarke and Dix (239) have developed an analysis procedure based on the work of Jones and others (7), which focuses on the dynamic aspects of life-cycle; individuals and households evolve from one stage in the family life-cycle to another over time (or move from segment to segment). Life-cycle has proved to be an important segmentation basis in studies of activity patterns.

Life-cycle segmentations have rapidly acquired considerable popularity. Their influence is to be found in both data-collection and analysis procedures. It can also be extended as a framework for considering the implications of policies for the different life-cycle groups. However, reservations have been expressed by Brög (240) and Morris (241) about a possible overreliance on a concept such as life-cycle in explaining patterns in travel behavior to the exclusion of other important explanatory variables. Moreover, nonconforming households, which have increasing relevance, are not usually adequately accounted for in such approaches.

Life-style is another variable complex that has been effectively used as a segmentation base in marketing research (242). However, this concept is more difficult to implement because of ambiguities in definition and because of data requirements (243). In its most ambitious form, life-style incorporates the concepts of social class and basic selections among alternative living arrangements and types of leisure-time activities. Life-style components have been used in travel-behavior analyses by Reed (244), Wachs (245) and his colleagues, Fried and others (246), Reichman (247), Kelly (248), and Salomon and Ben-Akiva (236). The results of these studies are encouraging. When the differences in the approaches are reconciled and combined with results from life-cycle analyses and analyses dealing with subjective components of life-style, this segmentation base should provide a useful foundation for applications in transportation planning.

Segmentations/Experiments

This category is modest in scope. Included are studies dealing with the development of segments that differentiate perceptions and beliefs about hypothetical new transportation products or services. These studies have been separated from the studies reviewed in the section Attitudes/Experiments in order to highlight the segmentation aspects of the approaches. The studies represent a merging of the subjects in the sections Attitudes/Simulations and Segmentations/Attitudes because the studies are attitudinally based.

It has long been demonstrated that segmentations based on behavioral intention are often related to differences in actual future consumer demand (249). At least two studies have used behavioral intention concerning use of a new or modified transportation mode as a segmentation criterion: Alpert and Davies (250) were unable to find distinct segments based on perception and belief data that explained differences in behavioral intention, but Tischer and Dobson (251) did find significant relationships. Dobson (223) attributes this difference in results to use of a single-response scoring of intention (250) and a multiple-response scoring (251).

Costantino and others (252) segmented populations on the basis of both socioeconomic characteristics and subjective beliefs; their objective was to explain differences in choices among hypothetical new transportation modes. Both segmentation bases produced significant improvements in the choice models. And in a series of studies testing different segmentation methodologies, Dobson and others (253), Dobson and Nicolaidis (254), and Dobson and Kehoe (255) analyzed beliefs about proposed new modes. In each study, segments were found with homogeneous profiles of preference, and the segments were interpretable in terms of differences in socioeconomic and activity-pattern characteristics. The major criticism of these approaches is the complexity of their methodologies and possible problems with the required data. Applications of simplified versions of these methodologies could be quite useful in assessing reactions to alternative transportation plans of many types, particularly if the segmentation methodologies were coupled with simulations of the type to be discussed in the introduction to the sections on experiments.

Segmentations/Choices

A number of studies have focused on segmentations based on choice constraints. Many of these studies are in the realm of time and space constraints or activity patterns and are discussed in the introduction to the sections on activities and in the section Segmentations/Activities. In the relatively over-studied realm of mode choice, choice constraint segmentations based on variables such as car ownership are common. Recker and Golob (256,171) and Recker and Stevens (172) proposed segmentations based on the perceived availability of each mode. The choice models estimated on the segments exhibited significantly greater explanatory power than

the models estimated on the total samples. Only limited comparisons were made between perceived and objectively measured constraints. This is a useful area for further study.

A completely different approach is to base segmentations on estimations of the probabilities that individuals will make certain choices. If such probability estimates are made in concordance with individual choice of the logit and probit genre, this translates into segmenting individuals on the basis of their calculated utility levels. This was proposed by Reid (257) and later carried out by Gensch (258). Gensch used standardized differences in logit-model utilities as a means of identifying a segment most likely to switch to public transit. The overall goal of the study was to develop an improved technique for use in transit marketing promotion. Further efforts along this direction appear to be warranted.

It is also possible to segment individuals directly on the basis of their observed choices. Such an approach was taken by Hensher (259): shoppers were segmented on the basis of their trip frequencies, and the resulting segments were found to be consistent with differences in socioeconomic characteristics. This represents an extension of the concept of behavioral-intention segmentation to the realm of actual choice. The most effective, unexplored use of this approach might be in interrelating different types of travel choices. That is, it might be used in exploring how segments representing differences in one type of travel behavior (say, trip frequency) are related to variances in another behavior (say, total time spent on travel).

Finally, Hauser and Urban (260) have provided perhaps the strongest methodological link between segmentation and choice. Their approach is experimental and is discussed in the section Experiments/Segmentations.

EXPERIMENTS

Approaches based on the collection and analysis of subjective judgments according to experimental designs are dealt with here. These approaches are variously called controlled simulations, controlled experiments, or laboratory simulations. The term "laboratory" is used figuratively, because data to support the approaches have been collected by using a variety of formats (such as home interviews and on-board surveys as well as questionnaires administered to respondents gathered at a central location or laboratory). Experimental approaches were developed by psychologists and have been used extensively in marketing research. Their use in travel-behavior analysis is just emerging.

Data collections involve judgments by respondents about alternatives that are defined within a predetermined set of hypothetical situations. These situations are generated by a design-of-experiments plan in which the variables of interest are systematically manipulated. [The theory of design of experiments is described in detail in texts by Cochran and Cox (261) and Winer (262); uses in marketing research have been described by Green (263).] In travel-behavior analysis, the variables of interest are typically the characteristics (attributes) of travel modes, destinations, etc. The specific nature of the survey task depends on the data analysis method being used. A comprehensive overview of alternative methods is provided by Green and Srinivasan (264). In the field of travel-behavior analysis, overviews are provided by Hensher and Louviere (265), Levin (98,108), and Louviere and others (100,266) in the course of describing the use of a particular method.

The experimental approach is one of stated preference rather than revealed preference because no direct observations of real-world behavior are used in estimating the models. Consequently, debates regarding the relevance of experimental approaches are often on the level of dogmatic beliefs in the value of stated versus revealed preferences. This might be fortunate or unfortunate, depending on one's view of scientific progress, but it has surely led to rather sweeping statements on the issue. From the point of view of proponents of experimental approaches, Louviere and others write (266):

> We regard it as unfortunate that, despite five years of highly successful validity tests, simulation methods remain generally unaccepted and are forced to take a back seat to more traditional econometric methods. Although paradigms are slow to change, it is hard to understand the resistance to methods that have a good record in numerous validity tests over an extended period of time. Simulation models are at least as accurate as revealed-behavior models, offer greater flexibility in both data collection and analysis, and allow stronger model tests.

If this statement holds up only partly under cross-examination, the current approaches deserve careful consideration.

There is no precise criterion with which to classify specific methods under the broad heading Experiments. The decision here is to discuss within these sections methods that typically involve presenting respondents with full combinations of variables. Methods that involve presenting respondents with comparisons between pairs of variables (attributes of choice alternatives) are dealt with in the section Attitudes/Experiments.

Experiments/Activities

There do not appear to be any studies that fit into this category. It is useful to ask why this is so. One answer might be that activity approaches have only recently become popular. Consequently, the attention of the experimentalists, another segment of the research community, has not yet been drawn in the activity direction. Rather, their attention remains largely drawn in the direction of mode choice, an overemphasis that has plagued travel-behavior analysis throughout its history.

There is every reason to believe that studies applying experimental approaches to activity preferences and choice behavior would be quite useful. It is possible to imagine studies in which respondents are presented with situations involving choices among alternative activity patterns under varying conditions in accordance with a design-of-experiments plan. Much might be learned about the structure of activity preferences. As is discussed in Experiments/Attitudes, experimental approaches have proved to be particularly effective in identifying nonlinearities in preference structures. Experimental approaches thus appear to be ideally suited for activity applications because a substantial degree of nonlinearity can be expected in activity preferences. These nonlinearities might include noncompensatory decision rules, interactions between variables, and threshold effects (particularly related to satisfactions of compulsory activities).

Experiments/Attitudes

It is a basic premise in the experimental approaches reviewed in this section that the most valid subjective responses are those that are elicited when

respondents view variables taken together in various combinations, not alone or in pairwise comparisons. Such approaches are known as full-profile approaches (264) and at least three types have been applied in analyzing travel behavior: functional measurement, conjoint measurement, and magnitude estimation. These methods are ordered in terms of apparent number of published studies in the field of transportation research. (The second category of experimental approaches, two-factor-at-a-time methods, is discussed in the section Attitudes/Experiments.)

Functional measurement, also called information-integration theory (267), uses analysis-of-variance techniques to estimate the values (or utility weights) for levels of the attributes under study. Typically, respondents are asked to provide preference ratings for hypothetical alternatives on a bad-to-good scale of 1 to 20 or 1 to 100. As in the other full-profile approaches, the hypothetical alternatives are specified in terms of a design-of-experiments plan. Important aspects of the approach include the ability to detect interaction effects and noncompensatory combinations of attributes and the ability to rigorously test alternative model hypotheses. (Methodological comparisons between functional measurement and other approaches are provided in many of the overviews cited in the introduction to the sections on experiments.)

Functional measurement has been applied to mode choice for home-to-work trips and long-distance travel, destination choice, residential location choice, and a variety of other choices in a series of separate studies: those by Levin and others (268), Meyer and others (269), Louviere and Meyer (270), and Levin and Herring (271), among others. Benjamin and Sen (272) compared functional measurement with conjoint measurement trade-off analysis and unidimensional scaling and concluded that functional measurement was most effective. Many of these studies have involved checks of functional-measurement results against revealed choices; the outcomes have been encouraging. Stated preferences were found to be related to choices but not in a linear manner. The researchers failed to follow up in assessing the influence of this nonlinear relationship on estimations of choice-based attribute values, but steps were taken to relate function-measurement results directly to choice through use of a conventional logit model (273). More recently, Louviere and others (266) compared predictions of mode choice by using functional-measurement results against those of a logit model based on revealed-choice data for the same subjects; the two approaches performed about equally well, but functional measurement supplied more information about attribute elasticities.

The second approach, conjoint measurement (274), has had only a few applications in travel-behavior analysis. It is similar to functional measurement but requires only rank-order preferences from respondents, which is an easier survey task. The methodology involves a type of scaling algorithm that is similar to the algorithms tested in the travel-behavior field by Dobson and others (253) and by Dobson and Kehoe (255). Because there is less information in the survey data, conjoint measurement is more restricted in its ability to test for alternative rules of attribute combinations and to detect interaction and threshold effects. However, recent methodological developments that have not yet found their way into transportation applications appear to have alleviated some of the shortcomings [Green and Srinivasan (264) review early stages in some of these developments.]

Conjoint measurement has been used by Davidson (275) to forecast demand for alternative configurations of proposed new forms of air travel. It has also been used by Steer and Willumsen (276) to forecast the effects of alternative modifications in rail timetables. There are numerous other applications in marketing research.

The third approach is called magnitude estimation (277). Respondents are asked to provide scale judgments about the ratio of preferences between two hypothetical alternatives. Because this survey task might prove difficult in complicated choice situations, the approach has typically been applied to choices among familiar alternatives. The analysis methodology is based on generalized least-squares regression and is extremely effective in detecting and testing threshold and interaction effects. It is closely related to the approach known as clinical judgment analysis (278). Magnitude estimation has been successfully applied by Horowitz (279,280) in estimating relative weights for the components of bus travel--travel, waiting, walking, and transfer time--under various conditions of weather, seating availability, etc. The approach was also used by Pullian and others (281) in a less extensive investigation of relative weights among trip components.

There are a number of other full-profile approaches described in the psychological and marketing research literature. One approach, involving segmentation, is discussed in the section Experiments/Segmentations. Some other approaches are discussed in the references cited in the introduction to the sections on experiments. We are not aware of any major applications of them in travel-behavior analysis. Nor would such applications be expected to be unusually productive. The three approaches already available have each been shown to be robust, so variations on the theme should not be needed. Instead, tests similar to that conducted by Benjamin and Sen (272) might be conducted to compare the three approaches in different behavioral contexts.

Indeed, there seems to be a dearth of effort to resolve minor differences among approaches in the transportations applications of these methods. Green and Srinivasan report that studies in marketing research aimed at comparing alternative approaches have revealed that the approaches yield similar predictions. Results seem to be most sensitive to the structure of the survey task and the choice context. Comparisons of alternative survey tasks should be conducted in the realm of travel behavior.

Experiments/Segmentations

Population segmentations are easily incorporated into experimental approaches of the type discussed earlier. This is one of the advantages of experimental designs: to be able to test differences among respondents within the same methodology used for estimation of variable effects. In addition, many of the multivariate statistical techniques used in the studies reviewed in the introduction to the sections on segmentations can also be used to explore differences among response profiles in experimental data.

However, only a few experimental studies have included segmentations. This is probably due to the nature of the data: Often, either a homogeneous sample of convenience (students) is used in testing and refining an approach or an application calls for a study of the behavior of a predefined segment. Fortunately, examples are available, and these include the functional measurement study by Meyer and others (269) and the trade-off analysis study by Donnelly (282). In a study of mode choice between car and bus, Meyer and others found that their sample could be effectively divided into three segments on the basis of preference profiles; these

were a car-based segment, a bus-based segment, and an unbiased segment. These results are similar to ones found by using nonexperimental approaches [see study by Dobson and Tischer (212), for example].

A different type of experimental approach involving segmentation was developed by Hauser and Urban (283). It is based on axiomatic utility theory (284), in which the structure of preferences is derived deductively from a set of assumptions. In the Hauser and Urban approach, individuals are segmented on the basis of criteria similar to the benefit segmentation discussed earlier. Parameters of the preference structures are then estimated from responses to prespecified lotteries. This approach has not been widely adopted in travel-behavior analysis.

Methodologically, there have been some new developments in marketing research that hold forth the promise of more effective segmentations in experimental approaches. These new developments do not appear to have reached the field of travel-behavior analysis. Specifically, a technique called componential segmentation (285) is aimed at predicting individual preferences from joint analyses of respondent profiles and the attribute profiles typically used in experimental approaches. Tests of travel-behavior applications of such new marketing research techniques are likely to yield useful results.

Experiments

We know of no studies that qualify for this category. According to the definitions employed in this review, studies in this category would represent the ultimate in travel-behavior analyses. These would be approaches in which experimental designs were used to specify combinations of levels of objectively measured variables, such as travel times, walking distances, costs, and physical vehicle designs in the mode-choice context. Then respondents would be presented with actual real-world choice alternatives representing these combinations, and choice would be monitored. Viewed another way, these approaches would extend the subjective survey tasks of the types described in the sections dealing with experiments and attitudes to real-world situations. Such experiments are expensive but not infeasible.

Demonstration projects of the kind undertaken to evaluate new transportation hardware and operating strategies might serve as a basis for true behavior experiments. But such demonstration projects have not generally been structured in such a way as to allow determination of underlying causes in changes in travel behavior. Needed are careful experimental designs and before-and-after surveys to monitor behavioral changes. Simpler experimental designs of the type used in trade-off analysis might be envisioned as a starting point in using demonstrations in this way.

Experiments/Choices

Recently, it has been demonstrated that experimental approaches can be used to estimate discrete-choice models such as the multinomial logit model. This is potentially an important development, because it marries two previously different philosophies of travel-demand analysis and opens up possibilities for extensions of choice modeling.

The development of experimental approaches to choice modeling has proceeded along two paths. One approach is based on a level of data aggregation that is analogous to that used in conventional disaggregate travel-demand models (this is referred to here as the group-level approach). The second approach operates on the individual level; a separate choice model is estimated for each respondent. This level is more consistent with that used in the descriptive techniques that have explored the role of time and space constraints on travel behavior: The focus is on representative travelers rather than on the average across groups of travelers. These two experimental approaches to choice modeling share many methodological considerations.

In both approaches, a design-of-experiments plan is used in which the levels of the independent variables and choice set compositions are systematically manipulated. Respondents are thus presented with predetermined choice situations and asked to choose among the alternatives specified as being available, where these available alternatives are characterized by different levels of the independent variables (such as times and costs). The experimental design makes it possible to control the intercorrelations among the variables and between the variables and choice set compositions. This allows precise satisfaction of some of the assumptions underlying discrete-choice models (286) and it allows rigorous testing of independent and interactive variable effects. Both approaches then use a generalized (weighted) least-squares estimation technique to estimate multinomial logit models from the experimental data. [The estimation method was developed by McGuire and others (287) and Grizzle and others (288) and involves a specific set of dummy regression variables required by the transformation of the logit model to a linear system; these variables are explained by Batsell and Krieger (289) and are illustrated by Louviere and Hensher (290).]

The group-level approach was introduced into travel-behavior analysis by Louviere and Hensher (290). These authors document several applications, many of which involved successful validations of results with external evidence of real-world choice behavior. The approach provides the same type of information that is provided by choice-model estimations by using revealed-choice data: variable coefficients and associated standard errors for the sample being studied. The approach translates into the realm of experiments the method of estimating logit models from contingency tables. This estimation method has been developed in marketing research by Green and others (291), Flath and Leonard (292), and others and has been used in analyzing travel behavior by Segal (293). It is in turn related to log-linear analyses of contingency tables commonly used in social science research (294,295).

The individual-level approach was developed in marketing research by Batsell (296) [also by Batsell and Lodish (297)]. In this approach a separate logit model is estimated for each respondent based only on his or her choices. Respondents are then segmented according to similarities and differences in model structure. Apparently, this approach has not yet been applied in travel-behavior analysis.

The two approaches are complementary. They each impose a slightly different requirement on experimental design. The group-level approach might be envisioned in choice situations in which there are quite a few candidate independent variables. Fractional experimental designs can be used to reduce the number and still secure information regarding most of the effects of the variables. The individual-level approach might be envisioned as a segmentation technique, where the objective is to explore structures in previously unmodeled choice contexts. The activity-based analyses discussed in the section Activities appear to have identified a number of such contexts. Small experimental individual-level choice studies might be usefully com-

missioned there. In any event, either of the current approaches provides a low-cost alternative to the estimation of choice models by using revealed-choice data.

CHOICES

In this last major section, we review approaches that focus primarily on models of individuals' choices. Our objective is, as before, to compare alternative travel-behavior approaches by cross-classifying this subject area with the other four subject areas. However, this section is limited by the omission of the section that would have reviewed developments in the area of travel behavior that has come to be regarded as standard methodology: probabilistic models of choice of mode trip, frequency, car ownership, or residential location (nested or otherwise) based on objectively measured variables and using revealed-choice estimation procedures. It would obviously need to be a very large section.

This exclusion does not represent a judgment about the value of these approaches. Rather, it represents a division of labor between the current review and others. (It also represents our inability to fully appreciate the important nuances of the choice-modeling approaches.) Reviews that focus on studies of that type, but that also cover some of the research classified into the following sections are provided by Daganzo (298), Daly (299), Hensher and Johnson (300), Manski (301), Horowitz (paper in this Report), and Lerman (paper in this Report). These reviews are all quite comprehensive and are considered to be complementary to this one.

Choices/Activities

This category covers travel-behavior studies that focus on modeling activity-related choices. There is a gray area between the coverage of this section and that of the section Activities/Choices. The intention in the latter was to review studies that focus mainly on simultaneous choices among a complex of activity components with correspondingly less detailed specifications of choice related to any particular travel component. This section deals with choice models for particular components of activity patterns, often trip chains or tours. This is recognized as a rather arbitrary distinction. Indeed, some studies [such as the one documented by Adler and Ben-Akiva (302)] span both sections. Nevertheless, each study is reviewed either in one section or in the other, not in both.

Important early activity-choice studies were those of MacKay (303) and Maw (304). MacKay developed and tested a three-stage model involving (a) the decision to generate a shopping trip during a specific time period, (b) the number of stops to be made, and (c) which type of establishment would be visited at each stop. Maw developed a conceptual model of recreation activity choice based on the concept of variable blocks of free time during a day. The model incorporated several other types of choice constraints as well (which represents an extension of some of the concepts described in the section Segmentations/Choices). Time of day of travel was also modeled for the journey-to-work choices by Abkowitz (305,306).

The modeling of certain aspects of activities through the definition of trip tours (round-trip journeys) rather than trips as choice alternatives was pursued in a study documented by Daly (307), Weisbrod and Daly (308), and Daly and van Zwam (309). This study demonstrated how the realm of disaggregate travel-demand models involving choice of travel frequency, destination, mode, and time of day can be extended from trips to trip tours. In another study exploring the possibilities and limitations of existing choice models, Ben-Akiva and others (310) developed a model for non-home-based travel, which focused on the choice of whether to return home from a given location.

In a series of choice studies, Horowitz (311-314) explored travel behavior involving multiple-destination trips. The first study was concerned with the frequency and destination characteristics of nonwork car travel. This was extended in the second study to a nonwork disaggregate demand model, which related trip-tour frequency, destination choice, and choice of the number of stops to household characteristics, destination characteristics, and transportation level of service. Finally, Horowitz (314) specified a similar modeling system that includes both work and nonwork travel and is used to assess the impacts of alternative fuel-allocation policies.

Other approaches to modeling interrelated, activity-based travel choices are reported by Lerman (315), Lerman and others (316), and Adler and Ben-Akiva (302). Lerman (315) developed a joint mode-destination choice model for nonwork travel by merging a logit model with a model of semi-Markov processes. The model uses probability distributions of dwell times at home and nonhome destinations to determine trip departure times. Taking a different approach, Adler and Ben-Akiva developed a model that included trade-offs between single- and multiple--destination trips and, importantly, covered travel over an entire day. The model was based on a theoretical derivation of a household's desires for nonhome activities, taking into account household resources and travel expenditure functions. It extends the type of theoretical arguments fashioned by Burns and Golob (317) in developing the concept of accessibility.

Choices/Attitudes

An important merging of choice modeling and attitude analyses has been the application in choice models of alternative decision rules. It is well known that virtually all disaggregate travel-demand models are based on utility maximization. There are reasons to believe that this decision rule might not apply in all choice circumstances (318-320). Different decision rules have been developed by referring to psychological theories. These same and related theories underlie many of the attitudinal studies discussed in the introduction to the sections on attitudes in this review. Moreover, the different decision rules have been typically applied through the use of subjective variables. Application by using only objectively measured time and cost variables remains a subject largely for future research.

As an alternative to the development of different decision rules, several studies have focused on modifications to conventional utility-maximizing models in order to make the models more consistent with known perception phenomena. Researchers such as Sen (321), Hensher and Johnson (320,322), Lerman and Louviere (323), Koppelman (324), and Daly (325) have explored nonlinear variable combinations in utility-maximization models with encouraging results. Such transformations are consistent with nonlinear perceptions of time and space uncovered in the studies discussed in the section Attitudes/Activities and with results found in the simulation studies discussed in the section Attitudes/Experiments. Using a different approach, Krishnan (326) improved the explanatory power of a conventional mode-choice logit model by introducing the psychological concept of just-noticeable differences to

utility comparisons. Other approaches have been to introduce concepts of habit or choice inertia (327-330), search processes (331,332), and other types of threshold effects (333) into utility-maximization models.

Choice models in the field of travel behavior based on non-utility-maximizing rules have been developed by Foerster (334), Recker and Golob (335), Gensch and Svestka (336), and Young and Richardson (337). These studies all postulated noncompensatory choice models in which no direct trade-offs are assumed between characteristics of the choice alternatives. Characteristics are assumed to be considered one at a time by decisionmakers, which reflects constraints on human decisionmaking capacity (338) and a hierarchy of importances.

Foerster (334) compared different noncompensatory and compensatory decision rules for mode choice; the alternative models were estimated by numerical methods. Recker and Golob (335) implemented a choice model based on the concept of elimination by aspects (339), and Gensch and Svestka (336) used the same concept in a different, more pragmatic way. Finally, Young and Richardson (337) developed a probabilistic elimination-by-aspects model of residential choice. All of the models were compared with conventional logit models estimated by using the same survey data. It was unanimously concluded that the noncompensatory and compensatory (logit) models led to fundamentally different policy recommendations. This is an important result because it points out the need to question the basic assumptions underlying logit and probit choice models. These assumptions might be inappropriate in many contexts of travel behavior.

Choices/Segmentations

Segmentations typically underlie applications of travel-demand models. However, their use is often implicit, as in cross-classifications for trip generation, identifications of captive mode users, and aggregations of households by spatial zone. Indeed, spatial segmentations are fundamental to travel-behavior analyses. Examples of more explicit spatial segmentations are provided by Goddard (340), Simmons (341), Hanson and Marble (342), Wheeler (343), and Golob and others (344). In each of these studies, functional regions of homogeneous spatial interactions were determined by analyzing origin-destination flow matrices by using different multivariate statistical techniques. These regions (spatial segments) can be used in defining service areas for dial-a-ride systems or carpool matching assistance programs or for route-location studies.

The introduction of disaggregate demand models has called for the use of segmentations in aggregation procedures (298,345-348). For example, Dunbar (346) specified an aggregation procedure for mode-choice models that involved four steps (193): (a) defining segments with similar socioeconomic characteristics and levels of service, (b) determining the relative frequencies of each segment within the total population, (c) forecasting behavior for each segment by using average attribute values, and (d) aggregating by using steps b and c.

Finally, choice-based sampling, now a statistically well-understood means of estimating disaggregate models (349,350), can be considered a segmentation method. A potentially inherent problem with choice-based sampling becomes apparent when the technique is viewed in the segmentation context. This potential problem is a result of the phenomenon of differential perceptions and beliefs between users and nonusers of a given mode or in general between those who choose and those who do not choose an alternative. Studies reviewed in the section Attitudes/Segmentations have shown these differences to be measurable and pervasive. This might suggest the likelihood of certain biases in choice-based estimations and indicates the need for further research.

Choices/Experiments

In this category, the focus is primarily on choices, with a secondary focus on hypothetical choice situations. This characterizes those travel-behavior studies that use the approach referred to as transfer pricing or diversion pricing. These are of English and Australian origin. They involve asking respondents themselves to identify the amount of change in an attribute on their chosen alternative that would have to occur for them to consider another alternative.

This work was pioneered in the field of travel-behavior analysis by Lee and Dalvi (351). It was later adopted and expanded by Hensher (352,353). Most studies have been in the context of choice of mode for the journey to work. Although considerable insight has been gained into time and cost trade-offs by using this approach, there are certain inherent difficulties that have inhibited its wider application. Dalvi and Lee (354), Dalvi and Daly (355), and Bruzelius (356) discuss these difficulties from the point of view of value-of-time estimations.

Four difficulties can be readily identified. First, the approach is subject to the problems associated with attitude-behavior relationships in general and use of behavioral intention in particular; in addition, there is the problem of differentiating responses that imply considering behavioral changes from those that imply intending such changes. Second, results appear to be sensitive to the specific wording of the survey questions, including minor changes in the specification of the choice context (354,356). Fortunately, certain biases in responses are understood (357), and studies have been conducted to compare survey presentations (358,359). Third, there is the danger of attributing all of the differences between choice alternatives to differences in one or two characteristics for which transfer price responses are sought. And fourth, there are certain methodological problems involved in estimation (354,355).

More recent applications of the approach have involved its use as one part of a demand-forecasting study for Tehran (360) and its use in forecasting demand for proposed new modes (361). This latter study was concerned with the assessment of alternative strategies for carpooling incentives. It is of particular interest because it demonstrates how the approach might be applied in a broader context and relates transfer pricing to the approaches discussed in the section Experiments. It would be highly desirable to include transfer pricing in the research aimed at directly comparing alternative methods called for in that section's discussion.

CONCLUSIONS

A number of conclusions have emerged from this classification of analysis approaches. These conclusions have emerged through observations concerning the relative scarcity of approaches in particular cells of the classification matrix and from comparisons among the approaches in different cells. These comparisons were primarily among cells in the same rows or columns of the matrix. The conclusions are organized according to the anticipated research time frame.

In the short term, it might be fruitful to apply some of the results determined in the research classified into cell 2.1 (reviewed in the section Attitudes/Activities) in existing choice models of the cell-5.1 type. That is, known biases in perceptions of distance, time, and cost could be used to improve models involving trip tours, trip chains, and activity durations. Some nonlinear perception functions have been introduced in mode-choice models (Choices/Attitudes), but this work has not extended to the more activity-based choice models (Choices/Activities). There appears to be a wealth of information in the studies reviewed in Attitudes/Activities. In general, this information has not been consulted by choice modelers.

Next, it appears to be useful in the short term to continue efforts along the lines of the studies reviewed in the section Experiments/Choices. The estimation of logit-type choice models by using controlled simulations represents a cost-effective alternative to revealed-preference estimations. It is important to compare the results of the two approaches (that is, to compare approaches of the cell-4.5 and cell-5.5 types).

Finally, in the short term, there appears to be a possible problem with choice-based sampling techniques. This was revealed by consulting the studies reviewed in the section Attitudes/Segmentations in comparison to the choice-based sampling technique reviewed in the section Choices/Segmentations. A number of the cell-2.3 studies have concluded that there is a distinct difference in perceptions of chosen and nonchosen alternatives. This might affect choice models in general and choice models estimated by choice-based samples in particular.

In the longer term, further development of models of the type reviewed in the section Activities/Choices is deemed to be important. These models of activity-pattern choice are particularly relevant for many modern policy questions. It might be useful to apply some of the results from the segmentation studies reviewed in the section Activities/Segmentations in making the task more manageable.

Finally, the attention in laboratory-experiment studies of the functional-measurement or conjoint-measurement type could usefully be directed away from mode choice and related decisions and toward activity-pattern choice. This is viewed as both a short- and a long-term objective.

SUMMARY

In order to compare approaches to travel-behavior analysis, this review has attempted to cross-classify alternative approaches according to primary and secondary focus. Five primary-focus subjects have been used: activity-based approaches (Activities), approaches using subjective variables (Attitudes), approaches using population segmentations (Segmentations), approaches using controlled experiments (Experiments), and approaches directly involving choice models (Choices).

The resulting cross-classification can be depicted by a five-by-five matrix in which the rows represent the primary subjects and the columns the secondary subjects. Each cell in this matrix (except one) corresponds to a section in the review.

The following list summarizes the types of approaches to travel-behavior analysis that were judged to fall within each cell in the matrix. These types are listed here by their commonly used names. They are discussed in detail in the main body of the review, and references are provided.

1. Activities

   a. Activities (sole focus): quantification of time/space constraints; simulation models of activity duration; statistical analyses of activity patterns
   b. Activities/Attitudes: measures of activity commitment; role structures in activity programs
   c. Activities/Segmentations: analyses of activity-pattern differences by life-cycle segment; grouping of activity-pattern types; segmentations by travel time and money expenditures
   d. Activities/Experiments: HATS and other survey-simulation methods
   e. Activities/Choices: models of activity-pattern choice

2. Attitudes

   a. Attitudes/Activities: mental maps; perceptions of distance and time; use of learning theory
   b. Attitudes
   c. Attitudes/Segmentations: differences in attitudes among population groups; tests of cognitive dissonance
   d. Attitudes/Experiments: trade-off analysis; scaling of responses to hypothetical concepts
   e. Attitudes/Choices: attitude-behavior models; quantification of variable in choice models

3. Segmentations

   a. Segmentations/Activities: situational approach
   b. Segmentations/Attitudes: segments based on differences in preferences and perceptions
   c. Segmentations: segments based on life-cycle and life-style; comparisons of segmentation bases
   d. Segmentations/Experiments: segments based on behavioral intention
   e. Segmentations/Choices: choice-constraint segments; segments based on utility levels

4. Experiments

   a. Experiments/Activities
   b. Experiments/Attitudes: functional measurement; conjoint measurement; magnitude estimation
   c. Experiments/Segmentations: axiomatic utility theory; segments based on functional-measurement results
   d. Experiments
   e. Experiments/Choices: controlled simulations of logit models

5. Choices

   a. Choices/Activities: choice models with trip tours, trip chains, and trip timing
   b. Choices/Attitudes: non-compensatory choice models; choice models with nonlinear variable combinations
   c. Choices/Segmentations: segments used in choice-model aggregation; choice-based sampling
   d. Choices/Experiments: transfer-pricing approach

ACKNOWLEDGMENT

We extend our appreciation to Agatha van Baalen of the Netherlands Ministry of Transport and Fernanda Wagenaar and Geert Rozeboom of Bureau Goudappel Coffeng for their excellent preparation of this manuscript. Also, we wish to thank the staff of the Netherlands Ministry of Transport library and Hans

Cornelisse of Bureau Goudappel Coffeng for their help in locating references. Thanks in advance to all the readers who contribute to an improved version of this paper by pointing out to us our misrepresentations and oversights. It is important that we know the errors of our ways.

REFERENCES

1. K.P. Burnett. Markovian Models of Movement Within Urban Spatial Structures. Geographical Analyses, Vol. 10, 1978, pp. 142-153.
2. I.G. Heggie. Putting Behaviour into Behavioural Models of Travel Choice. Journal of the Operations Research Society, Vol. 29, 1978, pp. 541-550.
3. S.E. Hanson. The Importance of the Multi-Purpose Journey to Work in Urban Travel Behavior. Transportation, Vol. 9, 1980, pp. 229-247.
4. G.S. Root, M.G. McNally, W.W. Recker, and M.A. Smiley. Chaining Behavior in Urban Touring: A Critical Review. Institute of Transportation Studies, Univ. of California, Irvine, Rept. UCI-ITS-WP-82-2, 1981.
5. D. Damm. Theory and Empirical Results: A Comparison of Recent Activity-Based Research. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
6. D. Damm. The Integration of Activity and Transportation Analysis for Use in Public Decision Making. In Transport Research for Social and Economic Progress (J.S. Yerrell, ed.), Vol. 3e, Gower, London, 1980.
7. P.M. Jones, M.C. Dix, M.I. Clarke, and I.G. Heggie. Understanding Travel Behaviour. Transport Studies Unit, Oxford Univ., Oxford, England, 1980.
8. M.R. Wigan and J. Morris. The Transport Implications of Activity and Time Budget Constraints. Transportation Research, Vol. 15A, 1980, pp. 63-86.
9. P.M. Allaman. Activity Analysis: An Outline of Concepts and Methods. Presented at the 60th Annual Meeting, TRB, 1981.
10. L. Pickup and S.W. Town. The Role of Social Science Methodologies in Transport Planning. U.K. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, TRRL SR 698, 1981.
11. S. Carpenter and P.M. Jones, eds. New Approaches to Analysing Travel Behaviour. Gower, London, 1982.
12. J. Morris. Activity Approaches in Transport Analyses: Contributions, Conflicts and Challenges. Australian Road Research Board, Nunawading, Victoria, ARRB Project AIR 344-4, 1982.
13. G.S. Root and W.W. Recker. Toward a Theory of Complex Travel Behavior: An Activity-Based Formulation. Institute of Transportation Studies, Univ. of California, Irvine, Working Paper CB-4, 1982.
14. P.M. Jones. The Practical Application of Activity-Based Approaches in Transport Planning: An Assessment. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
15. W. Brög and E. Erl. Application of a Model of Individual Behavior (Situational Approach) to Explain Household Activity Patterns in an Urban Area and to Forecast Behavioral Changes. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
16. R.H. Knapp. Life Cycle Stages and the National Travel Surveys. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
17. T. Hägerstrand. What About People in Regional Science? Papers of the Regional Science Association, Vol. 24, 1970, pp. 7-21.
18. F.S. Chapin. Activity Systems and Urban Structure. Journal of the American Institute of Planners, Vol. 34, 1968, pp. 11-18.
19. F.S. Chapin. Human Activity Patterns in the City: Things People Do in Time and Space. Wiley, New York, 1974.
20. J.D. Nystuen. A Theory and Simulation of Intraurban Travel. In Quantitive Geography, Part I: Economics and Cultural Topics (W.L. Garrison and D.F. Marble, eds.), Northwestern Univ. Studies in Geography, Vol. 13, 1976, pp. 54-85.
21. R.K. Brail. Activity Systems Investigations: Strategy for Model Design. Univ. of North Carolina, Chapel Hill, Ph.D. thesis, 1969.
22. J.R. Ginn. Transportation Considerations in an Individual's Activity System. Northwestern Univ., Evanston, IL, Ph.D. thesis, 1969.
23. G.C. Hemmens. Analysis and Simulation of Urban Activity Patterns. Socio-Economic Planning Science, Vol. 4, 1970, pp. 53-66.
24. J. Tomlinson, N. Bullock, P. Dickens, P. Steadman, and E. Taylor. Model of Student's Daily Activity Patterns. Environment and Planning, Vol. 5, 1973, pp. 231-266.
25. O. Westelius. The Individual's Way of Choosing Between Alternative Outlets. Swedish National Council for Building Research, Stockholm, Document D17, 1973.
26. V. Vidaković. A Harmonic Series Model of the Trip Chains. In Transportation and Traffic Theory (D.J. Buckley, ed.), Elsevier, New York, 1974.
27. V. Vidaković. A Distance Parameter of the Trip-Chain Process. In Proc., Seventh International Symposium on Transportation and Traffic Theory (T. Sasaki and T. Yamaoka, eds.), Institute of Systems Science Research, Kyoto, Japan, 1977.
28. K. Kobayashi. An Activity Model: A Demand for Transportation. Transportation Research, Vol. 10, 1976, pp. 105-110.
29. K. Kobayashi. An Activity Model and Its Validation. In Behavioral Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
30. B. Lenntorp. Paths in Space-Time Environments: A Time-Geographic Study of Movement Possibilities of Individuals. Lund Studies in Geography, Series B, No. 44, 1976.
31. L.D. Burns. Transportation: Temporal and Spatial Components of Accessibility. D.C. Heath, Boston, 1978.
32. R. Kitamura, L.P. Kostyniuk, and J. Uyeno. Basic Properties of Urban Time-Space Paths: Empirical Tests. TRB, Transportation Research Record 794, 1981, pp. 8-19.
33. L.P. Kostyniuk and R. Kitamura. Basic Properties of Time-Space Paths of Urban Households: Empirical Tests. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
34. I. Cullen and V. Godson. The Structure of Activity Patterns. Joint Unit for Planning Research, Univ. College, London, Research Paper 1, 1972.
35. I. Cullen and V. Godson. Urban Networks: The Structure of Activity Patterns. In Progress in Planning (D. Diamond and J.B. MacLaughlin,

eds.), Vol. 4, (Part 1), Pergamon, Oxford, England, 1975.
36. G.A. Bentley, A. Bruce, and D.R. Jones. Intra-Urban Journeys and Activity Linkages. Socio-Economic Planning Science, Vol. 11, 1977, pp. 213-220.
37. M. Shapcott and C. Wilson. Correlations Among Time Uses. Transactions of the Martin Centre, Cambridge Univ., Vol. 1, 1976, pp. 73-94.
38. C.V. Oster. Household Tripmaking to Multiple Destinations: The Overlooked Urban Travel Pattern. Traffic Quarterly, Vol. 32, 1979, pp. 511-529.
39. C.V. Oster. The Second Role of the Work Trip: Visiting Non-Work Destinations. TRB, Transportation Research Record 728, 1979, pp. 79-81.
40. S.E. Hanson. The Importance of the Multi-Purpose Journey to Work in Urban Travel Behavior. Transportation, Vol. 9, 1980, pp. 229-247.
41. P.M. Jones, M.C. Dix, M.I. Clarke, and I.G. Heggie. Understanding Travel Behaviour. Transport Studies Unit, Oxford Univ., Oxford, England, 1980.
42. M.I. Clarke. The Formulation and Initial Development of an Activity Based Model of Household Travel Behaviour. Transport Studies Unit, Oxford Univ., Oxford, England, Working Paper 116, 1980.
43. A. Adiv. The Structure of the Work-Trip Based on Analysis of Trip Diaries in the San Francisco Bay Area. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
44. X. Godard. Presentation of Some Results of the Dijon Survey: Linkage Between Activities and Mobility. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
45. R. Herz. Stability, Variability and Flexibility in Everyday Behavior. In Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
46. F.S. Chapin. Human Time Allocation in the City. In Timing Space and Spacing Time (T. Carlstein, D.N. Parkes, and N.J. Thrift, eds.), Vol. 2, Arnold, London, 1977.
47. P.M. Jones. New Approaches to Understanding Travel Behaviour: The Human Activity Approach. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
48. E. Kutter. A Model for Individual Travel Behaviour. Urban Studies, Vol. 10, 1973, pp. 233-256.
49. E. Kutter. Individual Needs and Urban Structure Determinants of Behaviour Oriented Modèl Construction in Traffic Planning. In Transport as an Instrument for Allocating Space and Time (E. Matzner and G. Rüsh, eds.), Technische Universität Wien, Vienna, 1976.
50. E. Kutter. Some Remarks on Activity-Pattern Analysis in Transportation Planning. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
51. M. Fried, J. Havens, and M. Thall. Travel Behavior: A Synthesized Theory. NCHRP, Final Rept. 8-14A, 1977.
52. P.M. Allaman, T.J. Tardiff, and F.C. Dunbar. New Approaches to Understanding Travel Behavior. NCHRP, Rept. 250, 1982.
53. J.D. Stephens. Daily Activity Patterns and Time Space Constraints. Michigan State Univ., Lansing, MI, Ph.D. dissertation, 1975.
54. W. Brög, D. Heuwinkel, and K.H. Neumann. Psychological Determinants of User Behaviour. European Conference of Ministers of Transport, Paris, EMCT Round Table 34, 1977.
55. S. Reichman. Travel Adjustments and Life Styles--A Behavioral Approach. In Behavioral Travel-Demand Models (P.R. Stopher and A.H. Meyburg, eds.), D.C. Heath, Boston, 1976.
56. P.M. Allaman, F.C. Dunbar, and D. Steinberg. Impacts of Demographic Trends on Time Allocation for Household Activities. Presented at 60th Annual Meeting, TRB, 1981.
57. P. Hanson. The Activity Patterns of Elderly Households. Geographiska Annaler B, Vol. 109, 1978, p. 124.
58. S. Hanson and P. Hanson. The Impact of Social Roles on Urban Activity Patterns: The Case of Working Men and Women. Geographical Review, Vol. 70, 1980, pp. 291-299.
59. W.W. Recker, G.S. Root, M.G. McNally, M.J. Cirrincione, and H.J. Schuler. An Empirical Analysis of Household Activity Patterns. Institute of Transportation Studies, Univ. of California, Irvine, 1980.
60. W.W. Recker, M.G. McNally, and G.S. Root. Application of Pattern Recognition Theory to Activity Pattern Analysis. In New Approaches to Analysing Travel Behavior (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
61. E.I. Pas. Toward the Understanding of Urban Travel Behavior through the Classification of Daily Travel/Activity Patterns. Northwestern Univ., Evanston, IL, Ph.D. thesis, 1980.
62. E.I. Pas. Methodology for Analyzing Daily Travel and Activity Patterns. Presented at 61st Annual Meeting, TRB, 1982.
63. Y. Zahavi. The UMOT Model. Urban Projects Department, World Bank, Washington, DC, unpublished staff report, 1977.
64. Y. Zahavi. The UMOT Project. U.S. Department of Transportation, Rept. DOT-RSPA-DPB-20-79-3, 1979.
65. Y. Zahavi, M.J. Beckmann, and T.F. Golob. The UMOT/Urban Interactions. U.S. Department of Transportation, Rept. DOT-RSPA-DPB-10-7, 1981.
66. Y. Zahavi and J.M. Ryan. Stability of Travel Components over Time. TRB, Transportation Research Record 750, 1980, pp. 73-79.
67. Y. Zahavi and A. Talvitie. Regularities in Travel Time and Money Expenditures. TRB, Transportation Research Record 750, 1980, pp. 19-26.
68. G. Hoinville. Evaluating Community Preferences. Environment and Planning, Vol. 3, 1971, pp. 33-50.
69. H. Biel. The Journey-to-Work Game. Presented at the Annual Meeting of the Association of American Geographers, Washington, DC, 1972.
70. K.P. Burnett. Shopping Behavior in the Australian City: A Simulation Game. In Urban and Industrial Australia (J.P. Powell, ed.), Sorret, Melbourne, 1974.
71. P.M. Jones. "HATS": A Technique for Investigating Household Decisions. Environment and Planning A, Vol. 11, 1979, pp. 59-70.
72. P.M. Jones. Experience with Household Activity Travel Simulator (HATS). TRB, Transportation Research Record 765, 1980, pp. 6-12.
73. S.P. Phifer, A.J. Neveu, and D.T. Hartgen. Family Reactions to Energy Constraints. TRB, Transportation Research Record 765, 1980, pp. 12-16.
74. K.P. Burnett and S. Hanson. The Analysis of Travel as an Example of Complex Human Behavior in Spatially Constrained Situations: Definition and Measurement Issues. Transportation Research, Vol. 16A, 1982, pp. 87-102.

75. J.H. Bain. Activity Choice Analysis, Time Allocation and Disaggregate Travel Demand Modelling. Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA, M.S. thesis, 1976.
76. J. Jacobson. Models of Non-Work Activity Duration. Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA, Ph.D. thesis, 1978.
77. D. Damm. Interdependencies in Activity Behavior. TRB, Transportation Research Record 750, 1980, pp. 33-40.
78. D. Damm. Parameters of Activity Behavior for Use in Travel Analysis. Transportation Research, Vol. 15A, 1982, pp. 135-148.
79. D. Damm and S. Lerman. A Theory of Activity Scheduling Behavior. Environment and Planning A, Vol. 13, 1981, pp. 703-718.
80. T. Van der Hoorn. Travel Behaviour and the Total Activity Pattern. Transportation, Vol. 8, 1979, pp. 309-328.
81. T. Van der Hoorn. Development of an Activity Model Using a One-Week Activity-Diary Data Base. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
82. U. Landau, J.N. Prashkar, and M. Kirsh. The Effect of Temporal Constraints on Household Travel Behavior. Environment and Planning A, Vol. 13, 1981, pp. 435-448.
83. M.G. McNally and W.W. Recker. On the Formation of Household Travel/Activity Patterns: A Simulation Approach. Institute of Transportation Studies, Univ. of California, Irvine, Working Paper CB-3, 1982.
84. G.S. Root and W.W. Recker. Toward a Dynamic Model of Individual Activity Pattern Formulation. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
85. L.D. Burns. Transportation: Temporal and Spatial Components of Accessibility. D.C. Heath, Boston, 1979.
86. T.F. Golob, M.J. Beckmann, and Y. Zahavi. A Utility Theory Travel Demand Model Incorporating Travel Budgets. Transportation Research, Vol. 15B, 1981, pp. 375-390.
87. V. Vidaković. The Second Diary Survey in Amsterdam: Some Intermediate Results. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
88. M.J. Beckmann, T.F. Golob, and Y. Zahavi. Travel Probability Fields and Urban Spatial Structure. Environment and Planning A (in press).
89. D.T. Hartgen. Mode Choice and Attitudes: A Literature Review. New York State Department of Transportation, Albany, NY, Preliminary Research Rept. 21, 1970.
90. T.F. Golob. Attitudinal Models. In Urban Travel Demand Forecasting, TRB, Special Rept. 143, 1973, pp. 130-147.
91. T.F. Golob and R. Dobson. Assessments of Preferences and Perceptions Toward Attributes of Transportation Alternatives. In Behavioral Demand Modeling and Valuation of Travel Time, TRB, Special Rept. 149, 1974, pp. 58-81.
92. D.G. McFadgen. Transportation Mode-Choice Research: Recent Contributions from the Social Sciences. Travel Demand Forecasting Project, Univ. of California, Berkeley, CA, Working Paper 7502, 1975.
93. P.B. McLeod. The Role of Subjective Data Modelling Mode Choice. In Urban Travel Choice and Demand Modelling (D.A. Hensher, ed.), Australian Road Research Board, Nunawading, Victoria, Special Rept. 12, 1974.
94. R.M. Michaels. Behavioral Measurement: An Approach to Predicting Travel Demand. In Behavioral Demand Modeling and Valuation of Travel Time, TRB, Special Rept. 149, 1974, pp. 51-57.
95. B.D. Spear. Attitudinal Modelling: Its Role in Travel Demand Forecasting. In Behavioral Travel-Demand Models (P.R. Stopher and A.H. Meyburg, eds.), D.C. Heath, Boston, 1976.
96. D.A. Hensher and P.B. McLeod. Toward an Integrated Approach to the Identification and Evaluation of the Transport Determinants of Travel Choices. Transportation Research, Vol. 10, 1977.
97. D.T. Hartgen. Behavioral Science Applications to Issues in Transportation Planning. Presented at Conference on Applying Behavioral Science to Transportation Planning, Policy and Management, Charleston, SC, 1978.
98. I.P. Levin. The Development of Attitudinal Modelling Approaches in Transportation Research. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
99. J.J. Louviere. Attitudes, Attitudinal Measurement and the Relationship Between Attitudes and Behavior. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
100. J.J. Louviere, E.M. Wilson, and J.M. Piccolo. Psychological Modelling and Measurement in Travel Demand. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
101. M.C. Dix. Structuring Our Understanding of Travel Choices: The Use of Psychometric and Social-Science Research Techniques. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
102. M. Held. Some Thoughts about the Individual's Choice Among Alternative Travel Modes and Its Determinants. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
103. J.A. Michon and M. Benwell. Travelers' Attitudes and Judgments: Applications of Fundamental Concepts of Psychology. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
104. M.L. Tischer. Attitude Measurement: Psychometric Modeling. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
105. M.A. Johnson. Psychological Variables and Mode Choices Between Auto and Transit Travel: A Critical Research Review. Travel Demand Forecasting Project, Univ. of California, Berkeley, Working Paper 7509, 1975.
106. M.D. Stearns. Proceedings: TSC Workshop on Attitudinal Surveys for Transportation Planning and Evaluation. U.S. Department of Transportation, Rept. UMTA-MA-06-0049-75-1, 1975.
107. R. Dobson. Uses and Limitations of Attitudinal Modeling. In Behavioral Travel-Demand Models (P.R. Stopher and A.H. Meyburg, eds.), D.C. Heath, Boston, 1976.
108. I.P. Levin. New Applications of Attitude-Measurement and Attitudinal-Modeling Techniques in Transportation Research. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.

109. R.M. Michaels and P.M. Allaman. Research in Psychometrics: Potential for Applications and New Directions for Travel Modeling. In New Horizons in Travel Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
110. P. Gould and R. White. Mental Maps. Pelican Books, Harmonsworth, U.K., 1974.
111. J. Morris. Mental Maps of Victoria. Monash Univ., Clayton, Victoria, Australia, Monash Publications, No. 8, 1974.
112. F.E. Horton and D.R. Reynolds. Action Space Formation: A Behavioral Approach to Predicting Urban Travel Behavior. HRB, Highway Research Record 322, 1970, pp. 136-148.
113. D.B. MacKay, R.W. Olshavsky, and G. Sentell. Cognitive Maps and Spatial Behaviour of Consumers. Geographical Analysis, Vol. 7, 1975, pp. 19-34.
114. Y. Young and A.J. Richardson. Residential Area Location Preference Surfaces. TRB, Transportation Research Record 707, 1979, pp. 39-47.
115. G.B. Norcliffe. On the Use and Limitations of Trend Surface Models. Canadian Geographer, Vol. 13, 1969, pp. 338-348.
116. G. Rushton. The Scaling of Locational Preferences. In Behavioral Problems in Geography, A Symposium (K. Cox and R.G. Golledge, eds.), Northwestern Univ., Evanston, IL, Studies in Geography 17, 1969, pp. 197-227.
117. G. Rushton. Behavioral Correlates of Urban Spatial Structure. Economic Geography, Vol. 47, 1971, pp. 49-58.
118. F.S. Koppelman, J.N. Prashkar, and B. Bagamery. Perceptual Maps of Destination Characteristics Based on Similarities Data. TRB, Transportation Research Record 649, 1977, pp. 32-38.
119. R.G. Golledge, R. Briggs, and D. Demko. The Configuration of Distances in Intra-Urban Space. In Proc., Association of American Geographers, Washington, DC, 1969, pp. 60-65.
120. R. Briggs. Urban Cognitive Distance. In Image and Environment: Cognitive Mapping and Spatial Behavior (R.M. Downs and D. Stea, eds.), Aldine, Chicago, 1973.
121. D.T. Canter. Distance Estimation in Cities. Environment and Behavior, Vol. 7, 1975, pp. 59-80.
122. W. Young. Perceived Aspects of Location. In Proceedings of a Workshop on Measuring Social Behavior in Road Research (J. Morris, ed.), Australian Road Research Board, Nunawading, Victoria, 1980.
123. W. Young and J. Morris. Evaluation by Individuals of Their Travel Time to Work. TRB, Transportation Research Record 794, 1981, pp. 51-59.
124. J.E. Clark. Modeling Travelers' Perceptions of Travel Time. TRB, Transportation Research Record 890, 1982, pp. 7-11.
125. J.B. Lansing and G. Hendricks. How People Perceive the Cost of the Journey to Work. HRB, Highway Research Record 197, 1967, pp. 44-45.
126. P.N. O'Farrel and J. Markham. Commuter Perceptions of Public Transport Work Journeys. Environment and Planning A, Vol. 6, 1974, pp. 79-100.
127. M.C. Dix and P.B. Goodwin. Understanding the Effects of Changing Petrol Prices: A Synthesis of Conflicting Econometric and Psychometric Evidence. Presented at Summer Annual Meeting, PTRC Education and Research Services, Ltd., Warwick, England, 1981.
128. D.H. Henley, I.P. Levin, J.J. Louviere, and R.J. Meyer. Changes in Perceived Travel Cost and Time for the Work Trip during a Period of Increasing Gasoline Costs. Transportation, Vol. 10, 1981, pp. 23-34.
129. A. Adiv. Commuter's Versus Analyst's Perception of Automobile Travel Cost. TRB, Transportation Research Record 890, 1982, pp. 18-24.
130. W. Brög. Subjective Perception of Car Costs. TRB, Transportation Research Record 858, 1982, pp. 43-48.
131. R.G. Golledge and L.A. Brown. Search, Learning and the Market Decision Process. Geografiska Annaler, Vol. 49, 1967, pp. 116-124.
132. R.G. Golledge. The Geographical Relevance of Some Learning Theories. In Behavioural Problems in Geography (K.R. Cox and R.G. Golledge, eds.), Northwestern Univ. Press, Evanston, IL, 1969.
133. K.P. Burnett. The Dimensions of Alternatives in Spatial Choice Processes. Geographical Analysis, Vol. 5, 1973, pp. 181-204.
134. K.P. Burnett. The Dimensions of Alternatives in Spatial Choice Processes: A Reply. Geographical Analysis, Vol. 7, 1975, pp. 327-334.
135. S. Hanson. Urban-Travel Linkages: A Review. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
136. D. Swiderski. A Model for Simulating Spatially and Temporally Coordinated Activity Sequences on the Basis of Mental Maps. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
137. K.P. Burnett. New Methods of Data Analysis for Inductive Travel Behavior Modeling. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
138. M. Fishbein and I. Ajzen. Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. Addison-Wesley, Reading, MA, 1975.
139. R.L. Gustafson and F.P.D. Navin. User Preferences for Dial-a-Bus: A Comparison of Two Cities. General Motors Research Laboratories, Warren, MI, Research Publ. GMR-1217, 1972.
140. C.H. Lovelock. A Market Segmentation Approach to Transit Planning, Modeling, and Management. Proc., Transportation Research Forum, Vol. 16, 1975, pp. 247-258.
141. J.P. Byrd. Characteristics, Attitudes, and Perceptions of Transit Non-Users in the Atlanta Region. TRB, Transportation Research Record 563, 1976, pp. 29-37.
142. R. Dobson and M.L. Tischer. Beliefs About Buses, Carpools, and Single-Occupant Autos: A Market Segmentation Approach. Proc., Transportation Research Forum, Vol. 17, 1976, pp. 200-209.
143. A.D. Horowitz. A Cognitive Dissonance Approach to Additudinal Modeling in Travel Behavior Research. Presented at 57th Annual Meeting, TRB, 1978.
144. T.F. Golob, A.D. Horowitz, and M. Wachs. Attitude-Behaviour Relationships in Travel-Demand Modelling. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
145. M.L. Tischer and R.V. Phillips. The Relationships between Transportation Perceptions and Behavior over Time. Transportation, Vol. 8, 1979, pp. 21-36.
146. L. Festinger. A Theory of Cognitive Dissonance. Stanford Univ. Press, Stanford, CA, 1957.
147. D.J. Bem. Self-Perception: An Alternative

Interpretation of Cognitive Dissonance Phenomena. Psychological Review, Vol. 74, 1967, pp. 183-200.

148. T.F. Golob, E.T. Canty, R.L. Gustafson, and J.E. Vitt. An Analysis of Consumer Preferences for a Public Transportation System. Transportation Research, Vol. 6, 1972, pp. 81-102.

149. D.H. Gensch and T.F. Golob. Testing the Consistency of Attribute Meaning in Empirical Concept Testing. Journal of Marketing Research, Vol. 12, 1975, pp. 348-354.

150. J. Benjamin and L. Sen. Comparison of Predictive Ability of Four Multiattribute Approaches to Attitudinal Measurement. TRB, Transportation Research Record 890, 1982, pp. 1-6.

151. R.M. Johnson. Trade-Off Analysis of Consumer Values. Journal of Marketing Research, Vol. 11, 1974, pp. 121-127.

152. R.B. Ross. Measuring the Effects of Soft Variables on Travel Behavior. Traffic Quarterly, Vol. 29, 1975, p. 333.

153. E. Donnelly, S. Howe, and J. Deschamps. Trade-Off Analysis: Theory and Application to Transportation Policy Planning. High Speed Ground Transportation Journal, Vol. 11, 1977, pp. 93-110.

154. E. Donnelly. Preference Elasticities of Transit Fare Increases and Decreases by Demographic Groups. TRB, Transportation Research Record 580, 1976, pp. 30-35.

155. D. Weiss. Citizen Opinions on Public Transportation Roles, Service and Financing. TRB, Transportation Research Record 590, 1976, pp. 5-8.

156. D. Banister. Transport Mobility and Deprivation in Inter-Urban Areas. Univ. of Reading, England, Interim Rept. 7, 1978.

157. K.W.P. Koeppel and A.J. Neveu. Acid Test of the Trade-Off Method of Attitude Measurement. TRB, Transportation Research Record 765, 1980, pp. 22-27.

158. A.N. Sommers. Expanding Nondemographic Factors in Modal Split Models. Presented at National Meeting of the Operations Research Society of America, 1969.

159. T.F. Golob. The Survey of User Choice of Alternative Transportation Modes. High Speed Ground Transportation Journal, Vol. 4, 1970, pp. 103-116.

160. D.T. Hartgen and G. Tanner. Individual Attitudes and Family Activities. High Speed Ground Transportation Journal, Vol. 4, 1970, pp. 439-467.

161. D.T. Hartgen and G. Tanner. Investigations of the Effect of Traveller Attitudes in a Model of Mode Choice Behavior. HRB, Highway Research Record 369, 1971, pp. 1-14.

162. W.B. Allen and A. Isserman. Behavioural Modal Split. High Speed Ground Transportation Journal, Vol. 6, 1972, pp. 179-199.

163. M.J. Demetsky and L.A. Hoel. Modal Demand: A User Perception Model. Transportation Research, Vol. 6, 1972, pp. 293-308.

164. J.P. Wallace and A. Sherret. Estimation of Product Attributes and Their Importance. Lecture Notes in Economics and Mathematical Systems 89, Springer-Verlag, New York, 1973.

165. R.H. Ewing. Psychological Theory Applied to Mode Choice Prediction. Transportation, Vol. 2, 1973, pp. 391-410.

166. D.A. Hensher, P.B. McLeod, and J.K. Stanley. Usefulness of Attitudinal Measures in Investigating the Choice of Travel Mode. International Journal of Transport Economics, Vol. 2, 1975, pp. 51-75.

167. D.T. Hartgen. Attitudinal and Situational Variables Influencing Urban Mode Choice: Some Empirical Findings. Transportation, Vol. 4, 1974, pp. 377-392.

168. R.B. Westin and P.L. Watson. Reported and Revealed Preferences as Determinants of Mode Choice Behaviour. Journal of Marketing Research, Vol. 12, 1975, pp. 282-289.

169. K. Thomas. A Reinterpretation of the Attitude Approach to Transport Mode Choice and an Explanatory Empirical Test. Environment and Planning A, Vol. 8, 1976, pp. 793-810.

170. R. Dobson and M.L. Tischer. Comparative Analysis of Determinants of Modal Choices by Central Business District Workers. TRB, Transportation Research Record 649, 1977, pp. 7-14.

171. W.W. Recker and T.F. Golob. An Attitudinal Mode Choice Model. Transportation Research, Vol. 10, 1976, pp. 299-310.

172. W.W. Recker and R.F. Stevens. An Attitudinal Travel Demand Model for Non-Work Trips of Homogenously Constrained Segments of a Population. Transportation Research, Vol. 11, 1977, pp. 167-176.

173. M. Cadwallader. A Behavioural Model of Consumer Spatial Decision-Making. Economic Geography, Vol. 51, 1975, pp. 339-349.

174. D.B. McKay, R.W. Olshavsky, and G. Sentell. Cognitive Maps and Spatial Behavior of Consumers. Geographical Analysis, Vol. 7, 1975, pp. 19-34.

175. D.P. Costantino, T.F. Golob, and P.R. Stopher. Consumer Preferences for Automated Public Transportation Systems. TRB, Transportation Research Record 527, 1974, pp. 81-93.

176. T.F. Golob and W.W. Recker. Mode Choice Prediction Using Attitudinal Data: A Procedure and Some Results. Transportation, Vol. 6, 1977, pp. 265-286.

177. F.C. Bock. Factors Influencing Modal Trip Assignment. NCHRP Rept. 57, 1968.

178. C.A. Lave. A Behavioral Approach to Modal Split Forecasting. Transportation Research, Vol. 3, 1969, pp. 463-480.

179. P.L. Watson. Problems Associated with Time and Cost Data Used in Travel Choice Modeling and Valuation of Time. HRB, Highway Research Record 369, 1971, pp. 148-158.

180. G.C. Nicolaidis. Quantification of the Comfort Variable. Transportation Research, Vol. 9, 1975, pp. 55-66.

181. P.R. Stopher, B.D. Spear, and P.D. Sucher. Toward the Development of Measures of Convenience for Travel Modes. TRB, Transportation Research Record 527, 1974, pp. 16-32.

182. J.N. Prashkar. Development of a "Reliability of Travel Modes" Variable for Mode-Choice Models. Northwestern Univ., Evanston, IL, Ph.D. dissertation, 1977.

183. A.J. Neveu, F.S. Koppelman, and P.R. Stopher. Perceptions of Comfort, Convenience, and Reliability for the Work Trip. TRB, Transportation Research Record 723, 1979, pp. 59-63.

184. T.J. Tardiff. Causal Inferences Involving Transportation Attitudes and Behavior. Transportation Research, Vol. 11, 1977, pp. 397-407.

185. P.B. Goodwin. Habit and Hysteresis in Mode Choice. Urban Studies, Vol. 14, 1977, pp. 95-98.

186. D.J. Banister. The Influence of Habit Formation on Modal Choice--A Heuristic Model. Transportation, Vol. 7, 1978, pp. 5-18.

187. M. Voltenauer. Relevance of Attitudes and Problems of Measurement in the Field of Transportation. Proc., Deutsche Verkehrswis-

senschaftliche Gesellschaft Conference, Schliersee, 1977.
187a. F.J. Foerster, F. Young, and C. G. Gilbert. Longitudinal Changes in Public Preferences for Attributes of a New Transit System. Transportation Research, Vol. 11, 1977, pp. 325-336.
188. R. Dobson, F. Dunbar, C. Smith, D. Reibstein, and C. Lovelock. Structural Models for the Analysis of Traveler Attitude-Behavior Relationships. Transportation, Vol. 7, 1978, pp. 351-363.
189. J. Dumas and R. Dobson. Traveler Attitude-Behavior Implications for the Operation and Promotion of Transport Systems. TRB, Transportation Research Record 723, 1979, pp. 64-71.
190. M.L. Tischer and R.V. Phillips. The Relationship between Transportation Perceptions and Behavior Over Time. Transportation, Vol. 8, 1979, pp. 21-36.
191. D.J. Reibstein, C.H. Lovelock, and R. Dobson. The Direction of Causality Between Perceptions, Affect and Behavior: An Application to Travel Behavior. Journal of Marketing Research, Vol. 6, 1980, pp. 370-376.
192. E.P. Kroes. Attitudes and Mode Choice. Institute for Transport Studies, Univ. of Leeds, England, M.Sc. thesis, 1981.
193. W.B. Tye. Consumer Segmentation. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
194. R.R. Reed. Market Segmentation Development for Public Transportation. Department of Industrial Engineering, Stanford Univ., Stanford, CA, 1973.
195. C.H. Lovelock. A Market Segmentation Approach to Transit Planning, Modeling, and Management. Proc., Transportation Research Forum, Vol. 16, 1975, pp. 247-258.
196. D.A. Hensher. Use and Application of Market Segmentation. In Behavioral Travel-Demand Models (P.R. Stopher and A.H. Meyburg, eds.), D.C. Heath, Boston, 1976.
197. D.A. Hensher. Market Segmentation as a Mechanism in Allowing for Variability of Traveller Behavior. Transportation, Vol. 5, 1976, pp. 257-284.
198. J.J. Louviere, L.M. Ostresh, D.H. Henley, and R.J. Meyer. Travel Demand Segmentation: Some Theoretical Considerations Related to Behavioral Modelling. In Behavioral Travel-Demand Models (P.R. Stopher and A.H. Meyburg, eds.), D.C. Heath, Boston, 1976.
199. R. Dobson. Market Segmentation: A Tool for Transport Decision-Making. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
200. W. Brög. Behaviour as a Result of Individual Decisions in Social Situations. Proc., International Conference on Mobility in Urban Life, Arc-et-Senans, France, Institut de Recherche des Transport, Arcueil, France, 1978.
201. W. Brög. Latest Empirical Findings of Individual Travel Behaviour as a Tool for Establishing Better Policy-Sensitive Planning Models. In Transport Research for Social and Economic Progress (J.S. Yerrel, ed.), Vol. 3, Gower, London, 1980.
202. W. Brög and E. Erl. Interactive Measurement Methods: Theoretical Bases and Practical Applications. TRB, Transportation Research Record 765, 1980, pp. 1-6.
203. W. Brög and O. Förg. What Public Transportation Managment Should Know About Possible User Reactions. TRB, Transportation Research Record 746, 1980, pp. 30-35.
204. W. Brög. Application of the Situational Approach to Depict a Model of Personal Long-Distance Travel. TRB, Transportation Research Record 890, 1982, pp. 24-33.
205. W. Brög. The Acceptance of Policies to Encourage Cycling. TRB, Transportation Research Record 847, 1982, pp. 102-108.
206. G.C. Nicolaidis and R. Dobson. Disaggregated Perceptions and Preferences in Transportation Planning. Transportation Research, Vol. 9, 1975, pp. 279-295.
207. P.R. Stopher. The Development of Market Segments of Destination Choice. TRB Transportation Research Record 649, 1977, pp. 14-22.
208. G.C. Nicolaidis, T.F. Golob, and M. Wachs. An Evaluation of Alternative Market Segmentations for Transportation Planning. TRB, Transportation Research Record 649, 1976, pp. 23-31.
209. J.O. Summers and D.B. MacKay. On the Validity and Reliability of Direct Similarity Judgements. Journal of Marketing Research, Vol. 13, 1976, pp. 289-295.
210. A. Tversky. Features of Similarity. Psychological Review, Vol. 84, 1977, pp. 327-352.
211. T.X. Barber. Pitfalls of Human Research. Pergamon Press, New York, 1976.
212. R. Dobson and M.L. Tischer. Perceptual Market Segmentation Technique for Transportation Analysis. TRB, Transportation Research Record 673, 1978, pp. 145-152.
213. D.H. Gensch and P.T. Torres. Perceived-Difference Segmentation Model for Mass Transit Marketing. TRB, Transportation Research Record 765, 1980, pp. 16-22.
214. P.R. Stopher and G. Ergün. Population Segmentation in Urban Recreation Areas. TRB, Transportation Research Record 728, 1979, pp. 59-65.
215. V. Benjamin and L. Sen. An Evaluation of Public Transportation Using Market Segmentation Techniques. Journal of Advanced Transportation, Vol. 15, 1981, pp. 143-161.
216. T. Tardiff. Attitudinal Market Segmentation for Transit Design, Marketing and Policy Analysis. TRB, Transportation Research Record 735, 1979, pp. 1-7.
217. M. Fried, J. Havens, and M. Thall. Travel Behavior: A Synthesized Theory. NCHRP, Rept. 8-14A, 1977.
218. F.S. Koppelman, A.M. Tybout, and D. Syskowski. Role Inferences in Transportation Decision Making. In Women's Travel Issues: Research Needs and Priorities (S. Rosenbloom, ed.), U.S. Department of Transportation, 1978.
219. J.J. Havens. New Approaches to Understanding Travel Behavior: Role, Life Style, and Adaptation. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1982.
220. M. Davis. The 1976 Urban and Rural Travel Survey, Volume II: Summary of Findings; Attitudinal Data. California Department of Transportation, Sacramento, 1978.
221. R.L. Haley. Benefit Segmentatation: A Decision Oriented Research Tool. Journal of Marketing, Vol. 37, 1968, pp. 30-35.
222. V.H. Vroom. Work and Motivation. Wiley, New York, 1964.
223. R. Dobson. Market Segmentation: A Tool for Transport Decision-Making. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
224. R.M. Johnson. Market Segmentation: A Strategic Management Tool. Journal of Marketing Research, Vol. 8, 1971, pp. 13-18.
225. P. Kotler. Marketing Management. Prentice-Hall, Englewood Cliffs, NJ, 1972.

226. R. Rubin, J. Bruggeman, and F. Griffiths. Use of a Quantitative Marketing Model to Estimate Impact of Carpooling Policies. TRB, Transportation Research Record 650, 1979, pp. 54-59.
227. P.R. Stopher and J.O. Lavender. Disaggregate Behavioral Travel Demand Models: Empirical Tests of Three Hypotheses. Proc., Transportation Research Forum, Vol. 13, 1972, pp. 321-326.
228. D. Wells and G. Gubar. Life Cycle Concept in Marketing Research. Journal of Marketing Research, Vol. 3, 1966, pp. 355-363.
229. E. Aldana, R. deNeufville, and J.H. Stafford. Microanalysis of Urban Transportation Demand. HRB, Highway Research Record 446, 1974, pp. 1-11.
230. C. Bourgin. Changes in the Use of Transport Modes According to the Influence of Transition Moments in the User's Life-Cycle. Proc., International Conference on Mobility in Urban Life, Arc-et-Senans, France, Institut de Recherche des Transport, Arcueil, France, 1978.
231. P.R. Stopher and G. Ergün. Population Segmentation in Urban Recreation Choices. TRB, Transportation Research Record 728, 1979, pp. 59-65.
232. J.D. Downes. Life-Cycle Changes in Household Structure and Travel Characteristics. U.K. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, TRRL LR 930, 1980.
233. C. Bourgin and X. Godard. Structural and Threshold Effects in the Use of Transportation Modes. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
234. H.J. Collin. Significance of a Life Cycle Concept To Record Special Types of Leisure Travel Activities. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
235. R. Knapp. Life Cycle Stages and the National Travel Surveys. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P. Jones, eds.), Gower, London, 1982.
236. I. Salomon and M. Ben-Akiva. Life-Style Segmentation in Travel-Demand Analysis. TRB, Transportation Research Record 879, 1982, pp. 37-45.
237. M. Wigan. Vehicle Ownership in Australia as a Function of Composition and Household Lifecycle Stage. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
238. C. Zimmerman. The Life Cycle Concept as a Tool for Travel Research. Transportation, Vol. 11, 1982, pp. 51-59.
239. M. Clarke and M. Dix. Stage in Lifecycle--A Classificatory Variable with Useful Dynamic Properties. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P. Jones, eds.), Gower, London, 1982.
240. W. Brög. Behavior as a Result of Individual Decisions in Social Situations. Proc., International Conference on Mobility in Urban Life, Arc-en-Senans, France, Institut de Recherche des Transport, Arcueil, France, 1978.
241. J. Morris. Activity Approaches in Transport Analysis: Contributions, Conflicts, and Challenges. Australian Road Research Board, Nunawading, Victoria, AIR 344-4, 1982.
242. S.J. Levy. Social Class and Consumer Behavior. In On Knowing the Consumer (J.W. Newman, ed.), Wiley, New York, 1966.
243. Y. Wind and P. Green. Some Conceptual, Measurement and Analytical Problems in Life Style Research. In Life Style and Psychographics (W. Wells, ed.), American Marketing Association, Chicago, IL, 1974.
244. P. Reed. Life Styles as an Element of Social Logic: Patterns of Activity Social Characteristics and Residential Choice. Department of Sociology, Univ. of Toronto, Toronto, Canada, unpublished Ph.D. dissertation, 1976.
245. M. Wachs. The Changing Lifestyles and Travel Patterns of the Elderly. Univ. of California Press, Berkeley, 1980.
246. M. Fried, H. Havens, and M. Thall. Travel Behavior: A Synthesized Theory. NCHRP Rept. 8-14A, 1977.
247. S. Reichman. Instrumental and Life-Style Aspects of Urban Travel Bahavior. TRB, Transportation Research Record 649, 1977, pp. 38-41.
248. R. Kelly. Urban Life Style/Psychographics Research: Overview Implications for Transportation Planning. Presented at the 59th Annual Meeting, TRB, 1980.
249. E. Mueller. Effects of Consumer Attitudes on Purchase. American Economic Review, Vol. 50, 1957, pp. 946-965.
250. M.I. Alpert and C.S. Davies. Segmentation of a Market by Determinant Attributes. Council for Advanced Transportation Studies, Univ. of Texas, Austin, 1974.
251. M.L. Tischer and R. Dobson. An Empirical Analysis of Behavioral Intentions of Single Occupant Auto Driver to Shift to High Occupancy Vehicles. Transportation Research, Vol. 13A, 1979, pp. 143-158.
252. D.P. Costantino, R. Dobson, and E.T. Canty. Investigation of Modal Choice for Dual-Mode Transit. In Dual-Mode Transportation, TRB, Special Rept. 170, 1976, p. 67.
253. R. Dobson, T.F. Golob, and R.L. Gustafson. Multi-dimensional Scaling of Consumer Preferences for a Public Transportation System: An Application of Two Approaches. Socio-Economic Planning Sciences, Vol. 8, 1974, pp. 23-26.
254. R. Dobson and G.C. Nicolaidis. Preferences for Transit Service by Homogenous Groups of Individuals. Proc., Transportation Research Forum, Vol. 15, 1974, pp. 325-335.
255. R. Dobson and J. Kehoe. An Empirical Comparison of the Tucker-Messick and INDSCAL Models: Measuring Viewpoints About Transit Attributes. Socio-Economic Planning Sciences, Vol. 9, 1975, pp. 67-81.
256. W.W. Recker and T.F. Golob. A Behavioral Travel Demand Model Incorporating Choice Constraints. Advances in Consumer Research, Vol. 3, 1976.
257. F. Reid. Systematic and Efficient Methods for Minimizing Error in Aggregate Predictions from Disaggregate Models. TRB, Transportation Research Record 673, 1978, pp. 59-64.
258. D.H. Gensch. A Practical Segmentation Strategy to Increase Ride Sharing. Transportation Research, Vol. 15A, 1981, pp. 33A-337.
259. D.A. Hensher. Market Segmentation as a Mechanism in Allowing for Variability of Traveller Behavior. Transportation, Vol. 5, 1976, pp. 257-284.
260. J.R. Hauser and G.L. Urban. A Normative Methodology for Modeling Consumer Response to Innovation. Operations Research, Vol. 25, 1977, pp. 579-619.
261. W.G. Cochran and G.M. Cox. Experimental Designs, 2d ed. Wiley, New York, 1957.
262. B.J. Winer. Statistical Principles in Experimental Designs, 2d ed. McGraw-Hill, New York, 1973.
263. P.E. Green. On the Design of Choice Experiments Involving Multifactor Alternatives.

Journal of Consumer Research, Vol. 5, 1974, pp. 103-123.
264. P.E. Green and V. Srinivasan. Conjoint Analysis in Consumer Research: Issues and Outlook. Journal of Consumer Research, Vol. 5, 1978, pp. 103-123.
265. D.A. Hensher and J.J. Louviere. Behavioural Intentions as Predictors of Very Specific Behaviour. Transportation, Vol. 8, 1979, pp. 167-182.
266. J.J. Louviere, D.H. Henley, G. Woodworth, R.J. Meyer, I.P. Levin, J.W. Stoner, D. Curry, and D.A. Anderson. Laboratory-Simulation Versus Revealed-Preference Methods for Estimating Travel Demand Models. TRB, Transportation Research Record 794, 1981, pp. 42-51.
267. N.H. Anderson. Functional Measurement and Psychophysical Judgement. Psychological Review, Vol. 77, 1970, pp. 153-170.
268. I.P. Levin, M.K. Mosell, C.M. Lamka, B.E. Savage, and M.J. Gray. Measurement of Psychological Factors and Their Role in Travel Behavior. TRB, Transportation Research Record 649, 1977, pp. 1-7.
269. R.J. Meyer, I.P. Levin, and J.J. Louviere. Functional Analysis of Mode Choice. TRB, Transportation Research Record 673, 1978, pp. 1-7.
270. J.J. Louviere and R.J. Meyer. Behavior Analysis of Destination Choice: Theory and Empirical Evidence. Transportation Research, 1980.
271. I.P. Levin and R.D. Herring. Functional Measurement of Qualitative Variables in Mode Choice: Ratings of Economy, Safety, and Desirability of Flying versus Driving. Transportation Research, Vol. 15A, 1981, pp. 207-214.
272. J. Benjamin and S. Sen. Comparison of the Predictive Ability of Four Multiattribute Approaches to Attitudinal Measurement. TRB, Transportation Research Record 890, 1982, pp. 1-6.
273. S. Lerman and J.J. Louviere. Using Functional Measurement to Identify the Form of Utility Functions in Travel Demand Models. TRB, Transportation Research Record 673, 1979, pp. 78-86.
274. R.D. Luce and J.W. Tukey. Simultaneous Conjoint Measurement: A New Type of Fundamental Measurement. Journal of Mathematical Psychology, Vol. 1, 1964, pp. 1-27.
275. J.D. Davidson. Forecasting Traffic on STOL. Operational Research Quarterly, Vol. 24, 1973, pp. 561-569.
276. J. Steer and L. Willumsen. An Investigation of Passenger Preference Structures. In New Approaches to Analysing Travel Behaviour (S. Carpenter and P.M. Jones, eds.), Gower, London, 1982.
277. D.H. Krantz. A Theory of Magnitude Estimation and Cross-Modality Matching. Journal of Mathematical Psychology, Vol. 9, 1972, pp. 168-199.
278. R.M. Dawes and E. Corrigan. Linear Models in Decision Making. Psychological Bulletin, Vol. 81, 1974, pp. 95-106.
279. A.J. Horowitz. The Subjective Value of Time Spent in Travel. Transportation Research, Vol. 12, 1978, pp. 385-393.
280. A.J. Horowitz. The Subjective Value of Time in Bus Transit Travel. Transportation, Vol. 10, 1981, pp. 149-164.
281. R. Pullian, R.F. Pain, M.T. Schaffer, and J.L. D'Ignazio. Survey to Assess Public Perception of Values Critical to Transportation Planning. TRB, Transportation Research Record 617, 1976, pp. 13-18.
282. E. Donnelly. Preference Elasticities of Transit Fare Increases and Decreases by Demographic Groups. TRB, Transportation Research Record 589, 1976, pp. 30-32.
283. J.R. Hauser and G.L. Urban. A Normative Methodology for Modeling Consumer Response to Innovation. Operations Research, Vol. 25, 1977, pp. 579-619.
284. R.L. Keeney and H. Raiffa. Decision with Multiple Objectives: Preferences and Value Trade-Offs. Wiley, New York, 1976.
285. P.E. Green. A New Approach to Market Segmentation. Business Horizons, Vol. 20, 1977, pp. 61-73.
286. R.D. Luce. Individual Choice Behavior: A Theoretical Analysis. Wiley, New York, 1959.
287. T.W. McGuire, J.U. Farley, R.E. Lucas, and L.W. Ring. Estimation and Inference for Models in Which Subsets of the Dependent Variable Are Constrained. Journal of the American Statistical Association, Vol. 63, 1968, pp. 1201-1213.
288. J.E. Grizzle, C.F. Stormer, and G.C. Koch. Analysis of Categorical Data by Linear Models. Biometrics, Vol. 25, 1969, pp. 489-504.
289. R.R. Batsell and A.M. Krieger. Least-Squares Parameter Estimation for Luce-Based Choice Models. Marketing Department, Wharton School, Univ. of Pennsylvania, Philadelphia, Working Paper 79-022, 1979.
290. J.J. Louviere and D.A. Hensher. Design and Analysis of Simulated Choice or Allocation Experiments in Travel Choice Modeling. TRB, Transportation Research Record 890, 1982, pp. 1-6.
291. P.E. Green, F.J. Carmone, and D.P. Wachspress. On the Analysis of Qualitative Data in Marketing Research. Journal of Marketing Research, Vol. 14, 1977, pp. 52-59.
292. D. Flath and E.W. Leonard. A Comparison of Two Logit Models in the Analysis of Qualitative Marketing Data. Journal of Marketing Research, Vol. 16, 1979, pp. 533-538.
293. D. Segal. Discrete Multivariate Model of Work-Trip Mode Choice. TRB, Transportation Research Record 728, 1979, pp. 30-35.
294. S.J. Haberman. Loglinear Fit for Contingency Tables. Applied Statistics, Vol. 21, 1972, pp. 218-225.
295. C. Payne. The Log-Linear Model for Contingency Tables. In Analysis of Survey Data (C.A. O'Muircheartaigh and C. Payne, eds.), Wiley, New York, 1977.
296. R.R. Batsell. Consumer Resource Allocation Models at the Individual Level. Journal of Consumer Research, Vol. 7, 1980, pp. 78-87.
297. R.R. Batsell and L.M. Lodish. A Model and Measurement Methodology for Predicting Individual Consumer Choice. Journal of Marketing Rsearch, Vol. 18, 1981, pp. 1-12.
298. C.F. Daganzo. Calibration and Prediction with Random-Utility Models: Some Recent Advances and Unresolved Questions. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
299. A. Daly. Some Issues in the Application of Disaggregate Choice Models. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
300. D.A. Hensher and L.W. Johnson. Applied Discrete-Choice Modeling. Croom Helm, London, 1981.
301. C.F. Manski. Recent Advances in and New Directions for Behavioral Travel Modeling. In New Horizons in Travel-Behavior Research (P.R.

Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
302. J.J. Adler and M.E. Ben-Akiva. A Theoretical and Empirical Model of Trip-Chaining Behavior. Transportation Research, Vol. 13B, 1979, pp. 243-257.
303. D.B. MacKay. Consumer Movement and Store Location Analysis. Northwestern Univ., Evanston, IL, Ph.D. thesis, 1971.
304. R. Maw. Analysing Demand for Leisure Facilities. Built Environment, Vol. 1, 1972, pp. 519-522.
305. M.D. Abkowitz. An Analysis of the Commuter Departure Time Decision. Transportation, Vol. 10, 1981, pp. 283-287.
306. M.D. Abkowitz. Understanding the Effect of Transit Service Reliability on Work-Travel Behavior. TRB, Transportation Research Record 794, pp. 1981, 33-41.
307. A. Daly. Zuidvleugel Study: Report 1--Proposed Model Structure. Ministry of Transport and Public Works, the Hague, Netherlands, 1978.
308. G. Weisbrod and A. Daly. Zuidvleugel Study: Report 5--Initial Analysis of the Household Survey. Ministry of Transport and Public Works, the Hague, Netherlands, 1979.
309. A.J. Daly and H.H.P. van Zwam. Travel Demand Models for the Zuidvleugel Study. Presented at 61st Annual Meeting, TRB, 1982.
310. M.E. Ben-Akiva, L. Sherman, and B. Kullman. Non-Home Based Models. TRB, Transportation Research Record 673, 1978, pp. 128-133.
311. J. Horowitz. The Effect of Travel Time and Cost on the Frequency and Structure of Automobile Travel. TRB, Transportation Research Record 673, 1976, pp. 65-71.
312. J. Horowitz. Disaggregate Demand Model for Non-Work Travel. TRB, Transportation Research Record 673, 1978, pp. 65-71.
313. J. Horowitz. A Utility Maximizing Model of the Demand for Multi-Destination Non-Work Travel. Transportation Research, Vol. 14B, 1980, pp. 369-386.
314. J. Horowitz. Modeling Traveler Responses to Alternative Gasoline Allocation Plans. Presented at 60th Annual Meeting, TRB, 1981.
315. S.R. Lerman. The Use of Disaggregate Choice Models in Semi-Markov Process Models of Trip Chaining Behavior. Transportation Science, Vol. 13, 1979, pp. 273-291.
316. S.R. Lerman, M. Flusberg, W.M. Pecknold, R.E. Nestle, and N.H.M. Wilson. A Model System for Forecasting Patronage on Demand Responsive Transportation Systems. Transportation Research, Vol. 14A, 1980, pp. 13-23.
317. L.D. Burns and T.F. Golob. The Role of Accessibility in Basic Transportation Choice Behavior. Transportation, Vol. 5, 1976, pp. 175-190.
318. J.F. Foerster. Nonlinear Perceptual and Choice Functions: Evidence and Implications for Analysis of Travel Behavior. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
319. T.F. Golob and A.J. Richardson. Noncompensatory and Discontinuous Constructs in Travel-Behavior Models. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, eds.), D.C. Heath, Boston, 1981.
320. D.A. Hensher and L.W. Johnson. Applied Discrete-Choice Modelling. Croom Helm, London, 1981.
321. A. Sen, S. Sööt, and E. Patitsas. The Logit Modal Split Model: Some Theoretical Considerations. Transportation Research, Vol. 12, 1978, pp. 321-324.
322. D.A. Hensher and L.W. Johnson. External Structure of Variables in Individual Choice Models of Travel Demand. International Journal of Transportation Economics, Vol. 1, 1979, pp. 51-61.
323. S.R. Lerman and J.J. Louviere. Using Functional Measurement to Identify the Form of Utility Functions in Travel Demand Models. TRB, Transportation Research Record 673, 1979, pp. 78-86.
324. F.S. Koppelman. Non-linear Utility Functions in Models of Travel Choice Behavior. Transportation, Vol. 10, 1981, pp. 127-146.
325. A.J. Daly. Estimating Choice Models Containing Attraction Variables. Transportation Research, Vol. 16B, 1982, pp. 5-15.
326. K.S. Krishnan. Incorporating Thresholds of Indifference in Probabilistic Choice Models. Management Science, Vol. 23, 1977, pp. 1224-1233.
327. P.B. Goodwin. Habit and Hysteresis in Mode Choice. Urban Studies, Vol. 14, 1977, pp. 95-98.
328. P.B. Goodwin. Two Problems of Traveller Behaviour in Mathematical Models. Bulletin of the Institute of Mathematics and Its Applications, Vol. 15, 1979, pp. 11-12.
329. D.J. Banister. The Influence of Habit Formation on Modal Choice--A Heuristic Model. Transportation, Vol. 7, 1978, pp. 5-18.
330. J.H. Blase. Hysteresis in Travel Demand. Transportation Planning and Technology, Vol. 6, 1980, pp. 109-116.
331. D.A. Hensher. Perception and Commuter Modal Choice: An Hypothesis. Urban Studies, Vol. 12, 1975, pp. 101-104.
332. H.C.W.L. Williams and J.D. Ortuzar. Behavioural Travel Theories, Modal Specification, and the Response Error Problem. Presented at Summer Annual Meeting, PTRC Education and Research Services, Ltd., Warwick, England, 1979.
333. A.J. Daly. Some Issues in the Application of Disaggregate Choice Models. In New Horizons in Travel-Behavior Research (P.R. Stopher, A.H. Meyburg, and W. Brög, ed.), D.C. Heath, Boston, 1981.
334. J.F. Foerster. Mode Choice Decision Process Models: A Comparison of Compensatory and Non-Compensatory Structures. Transportation Research, Vol. 13A, 1979, pp. 17-28.
335. W.W. Recker and T.F. Golob. A Non-Compensatory Model of Transportation Behavior Based on Sequential Consideration of Attributes. Transportation Research, Vol. 13B, 1979, pp. 269-280.
336. D.H. Gensch and J.A. Svestka. An Exact Hierarchical Algorithm for Determining Aggregate Statistics from Individual Choice Data. Management Science, Vol. 25, 1979, pp. 939-952.
337. W. Young and A.J. Richardson. Residential Location Preference Models: Compensatory and Non-Compensatory Approaches. Presented at Summer Annual Meeting, PTRC Education and Research Services, Ltd., Warwick, England, 1980.
338. H.A. Simon. Models of Man: Social and Rational. Wiley, New York, 1957.
339. A. Tversky. Elimination by Aspects: A Theory of Choice. Psychological Review, Vol. 79, 1972, pp. 281-299.
340. J.B. Goddard. Functional Regions Within the City Centre: A Study by Factor Analysis of

Taxi Flows in Central London. Transactions of the Institute of British Geographers, Vol. 49, 1970, pp. 161-182.
341. J. Simmons. Interaction Patterns. Urban Affairs Quarterly, Vol. 5, 1970, pp. 213-232.
342. S. Hanson and D.F. Marble. A Preliminary Topology of Urban Travel Linkages. East Lakes Geographer, Vol. 7, 1971, pp. 49-59.
343. J.O. Wheeler. Trip Purposes and Urban Activities Linkages. Annals of the American Association of Geographers, Vol. 61, 1972, pp. 641-654.
344. T.F. Golob, S.J. Hepper, and J.J. Pershing. Determination of Functional Regions Within an Urban Area for Transportation Planning. TRB, Transportation Research Record 526, 1975, pp. 16-25.
345. F.S. Koppelman. Guidelines for Aggregate Travel Predictions Using Disaggregate Choice Models. TRB, Transportation Research Record 610, 1976, pp. 19-24.
346. F.C. Dunbar. Policy-Contingent Travel Forecasting with Market Segmentation. TRB, Transportation Research Record 637, 1977, pp. 27-32.
347. F.A. Reid. Minimizing Error in Aggregate Predictions from Disaggregate Models. TRB, Transportation Research Record 673, 1979, pp. 59-65.
348. Y. Dehghani and A. Talvitie. Model Specification, Model Aggregation, and Market Segmentation in Mode-Choice Models: Some Empirical Evidence. TRB, Transportation Research Record 775, 1980, pp. 28-34.
349. C.F. Manski and S.R. Lerman. The Estimation of Choice Probabilities from Choice Based Samples. Econometrica, Vol. 45, 1977, pp. 1977-1988.
350. C.F. Manski and D.L. McFadden. Alternative Estimators and Sample Designs for Discrete Choice Analysis. In Structural Analysis of Discrete Data: With Econometric Applications (C.F. Manski and D.L. McFadden, eds.), MIT Press, Cambridge, MA, 1980.
351. N. Lee and M.Q. Dalvi. Variations in the Value of Travel Time. Manchester School, Vol. 37, 1969.
352. D.A. Hensher. Valuation of Commuter Travel Time Savings: An Alternative Procedure. In Travel Time and Travel Choice (I.G. Heggie, ed.), Oxford Univ. Press, Oxford, England, 1976.
353. D.A. Hensher. The Value of Commuter Travel Time Savings. Journal of Transport Economics and Policy, Vol. 10, 1976, pp. 167-176.
354. M.Q. Dalvi and N. Lee. Variations in the Value of Travel Time: Further Analysis. Manchester School, Vol. 39, 1971, 187-204.
355. M.Q. Dalvi and A. Daly. The Valuation of Travelling Time: Theory and Estimation. Local Government Operational Research Unit Rept. T72, England, 1976.
356. N. Bruzelius. The Value of Travel Time: Theory and Measurement. Croom Helm, London, 1979.
357. M. Kurz. Experimental Approach to the Determination of the Demand for Public Goods. Journal of Public Economics, Vol. 3, 1974, pp. 329-348.
358. P. Böhm. An Approach to the Problem of Estimating Demand for Public Goods. Swedish Journal of Economics, Vol. 73, 1971.
359. P. Bohm. Estimating Demand for Public Goods: An Experiment. European Economic Review, Vol. 3, 1972.
360. S. Hansen and K.G. Rogers. The Role of Disaggregate Modelling Tools in the Policy Arena. In Behavioural Travel Modelling (D.A. Hensher and P.R. Stopher, eds.), Croom Helm, London, 1979.
361. P.W. Bonsall. The Simulation of Organized Car Sharing. Institute of Transport Studies, Univ. of Leeds, England, Working Paper 109, 1979.

Travel Behavior Models: State of the Practice

ROBERT E. PAASWELL and RICHARD M. MICHAELS, University of Illinois at Chicago

Transportation planning as a discipline must undergo significant changes to keep pace with the changes in our transportation systems. Strategic planning as envisioned in the 1960s is no longer practical or presumed to be needed. There is an obsession with project-level planning, caused both by a lack of resources and an emphasis on the measurement of costs and benefits of each decision mode and by an inability to understand or cope with long-term needs.

But is is precisely because we are undergoing rapid change--in population composition, economic structure, and geographical distribution, which simultaneously changes how we live, work, and play--that we need to develop procedures that will improve our abilities to conduct strategic planning.

At the same time, as we make those investment decisions that lay the groundwork for long-term change, we must be sure that we have all of the pertinent information to evaluate those investments.

The state of the practice of behavioral models at both short-term and long-term levels of planning is dealt with here. The need for a greater integration of the models with practice will be discussed and it will be shown which specific behavioral techniques can be used now.

Planning is approached in a hierarchical sense. After discussing the needs of strategic planning and short-term planning, we discuss social and economic change and then the influences on our thinking about planning. We raise specific questions linking planning and modeling that should be addressed by this workshop. Finally, we conclude with examples of behavioral modeling used in practice.

TRANSPORTATION PLANNING AND BEHAVIORAL ANALYSIS

The use of many behavioral techniques in transportation planning, analysis, and evaluation has been limited. Other than in travel behavior research, which has been extensive over the past decade, the applications of behavioral science methodology have not found their way into general practice. The only major exception has been in the application of dis-