U.S. Department of Transportation
Research and Special Programs Administration

A Manual of Procedures to Analyze Attitudes Toward Transportation

September 1982
DOT-RSPA-DMA-50/82/16

**Final Report
Under Contract
DOT-RC-92026**

Prepared by
Office of
University Research

This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-RSPA-DMA-50/82/16		

4. Title and Subtitle	5. Report Date
A Manual of Procedures to Analyze Attitudes Toward Transportation	August, 1982
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Julian Benjamin and Lalita Sen	A&T-TI-48-RR-82
9. Performing Organization Name and Address The Transportation Institute North Carolina A&T State University Greensboro, North Carolina 27411	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT-RC-92026
12. Sponsoring Agency Name and Address U.S. Department of Transportation; Research and Special Programs Administration; Office of University Research; 400 Seventh Street, S.W.; Washington, D.C. 20590	13. Type of Report and Period Covered Manual
	14. Sponsoring Agency Code DMA-50

15. Supplementary Notes

Technical Monitors: Mary Lynn Tischer, HHP-13 and
Carl Shea, HHP-22 (Federal Highway Administration)

16. Abstract

This is a manual which presents basic concepts of attitudinal measurement along with suggested applications. Methods are presented for analyzing attitudes on uni-dimensional scales as well as on multi-dimensional scales. Also included are methods for assessing preferences using various conjoint techniques.

Along with each method, sample questionnaires and fully analyzed exemplary problems are presented. References are provided which give an in-depth review of each technique, formulations and derivations of computational procedures and special-purpose computer programs where necessary.

Guidelines are also provided for selection of techniques for real-world implementation.

17. Key Words	18. Distribution Statement
Transportation planning Attitudinal measurement Consumer behavior Decision analysis	Document is available to the U. S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

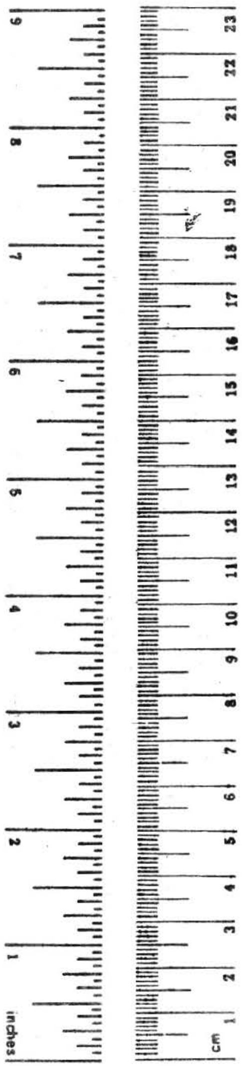
Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

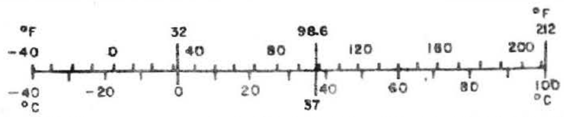
Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This manual presents a set of techniques used by transportation researchers, planners and analysts over the past decade. The techniques provide a wide range of capabilities for analyzing what people think about transportation.

The techniques listed here start with the most general approaches which analyze feelings about one element of transportation of a time and end with techniques that are capable of capturing feeling specific factors that influence transport decision.

The manual is not a complete text but it is rather an introduction to the conceptual background and potential applications of each technique. Some guidelines are also provided to help chose between techniques. References are provided at the end of each chapter, for the analyst who wants to utilize them. Special-purpose computer programs are also discussed where applicable. In-depth discussions of research methods and derivations of formulations are provided in the references as well.

It is hoped that this manual will be the first step for transport planners and managers toward the eventual utilization of these techniques to a wide range of transportation problems.

ACKNOWLEDGEMENTS

The author would like to convey his thanks to the many people who contributed to the development of this manual. Special credit must go to Mary Lynn Tischer and to Carl Shea who were the technical monitors with the U.S. Department of Transportation.

Additional thanks go to Dr. Arthur Saltzman, Institute Director, and to the staff of the Transportation Institute for their continued support throughout the project.

A special note of thanks to Richard Watt for assistance in compiling the appendix must be conveyed and to Debra Benjamin for editing the final draft of the manual.

Without these people, and the helpful comments of many others, the formation of this manual would not have been possible.

Julian Benjamin
Lalita Sen

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I -- INTRODUCTION

1.1. The purpose of the manual.

Transportation planning and the development of new transport systems depend on an assessment of the needs, desires and probable behaviors of the people for whom the system is intended. At the heart of human behavior are the feelings and emotions we all have. Our values are long term, stable beliefs that generally direct our behaviors and are a result of our life experiences. Feelings towards our immediate surroundings, preferences, satisfactions, and intended behaviors are all relatively short term, unstable attitudes that guide our daily behaviors. An accurate assessment of these attitudes in a population can only result from careful measurement and analysis of the responses of a representative sample of the population.

This manual describes several different attitudinal measurement techniques which have been used to measure attitudes towards transportation. Each of the techniques is discussed with respect to:

* The attitudes it measures
* Previous transportation-related applications
* Underlying assumptions and resulting data and analytical requirements
* Costs and benefits
* Questions, analysis and application to a transportation problem

The manual also compares the various techniques with guidelines for choosing between them. The manual is not written as a self-contained text, it is intended to be used with more complete discussions of the relevant mathematics and available computer codes, to which references are provided.

Much of the basic work in consumer-attitude research has been performed by psychologists and market researchers. Market researchers have developed these techniques to assist in the design, advertising and marketing of industrial products. Production planning and public transportation planning are similar processes. In each, consumer attitudes have a great deal to do with what products or services will best fit the needs and wants of consumers. Many of the basic references will be in market research and not specifically in transportation research.

1.2 Contributions of attitudinal measures to transportation decisions.

Decisions result from personal attitudes. Although consumer attitudes have been analyzed most frequently, decisions by transport suppliers can also be analyzed through the study of attitudes.

Demand for public transportation is the most frequent topic of attitudinal research. Most frequently studied is the choice between private automobile and bus, but attitudes towards various transit and paratransit modes have also been studied. Other topics include destination choice and route selection.

Demand for carrier services has also been studied. In this case, the consumer is the manufacturer or distributor of manufactured products. While the multiplicity of manufactured products and corresponding freight rates adds complexity, consumer behavior analysis is still applicable. In other applications, the attitudes of providers of transportation service have been analyzed to describe decisions about alternative service possibilities. In addition to these analyses of decision processes, attitudinal measures are helpful in analyzing the impacts of existing facilities or services. Typically, user satisfactions are a guide to the elements of a service that are most in need of improvement.

Resident attitudes are good indicators of community goals. Indicators of the importance of various transport attributes can be used to set goals for transportation improvements, systematically including the opinions of all parts of a community.

Finally, the effectiveness of changes in transportation services can be assessed by reviewing the attitudes towards these changes or towards the services before and after a change has occurred.

1.3. Use of attitudinal measures in the planning process.

The typical transportation planning model provides for:

a. setting goals and objectives

b. evaluating existing services

c. proposing alternative systems

d. forecasting demand for and benefits and costs of alternatives

e. selection and implementation of changes in the transportation system

f. evaluation of systems changes

Resident attitudes are useful indicators for each of the following steps in the planning process:

a. setting goals and objectives

b. evaluating existing services

c. forecasting demand and evaluating the benefits of proposed systems changes

d. evaluation of services after implementation.

Of the variety of attitudinal measurement techniques, some can be used in each different application. The researcher must carefully select the right technique for the right task.

1.4. <u>The relationship between attitudinal measures and usage</u>

Both the content of the question and the methodology directly depend on what is being investigated:

.. To set goals and objectives, questions should inquire about citizen values.

.. Service evaluation requires questions about satisfaction with existing facilities.

.. Travel demand analysis requires questions about preferences or intended usage.

Other uses require a similar match between usage and methodology. As each method is introduced, the uses for which it is best suited will be discussed.

1.5. <u>Use of consumer attitudes for information on various community groups.</u>

A representative sample of the community can, as a whole, be used to find attitudes of a cross-section of all residents. However, it is sometimes of interest to find the opinions of groups within the community, such as those defined by income, geographical location or physical handicap. In fact, groups of residents can be formed on the basis of the similarity of their viewpoints.

In summary, a wealth of information can be obtained by studying attitudes, and attitudes are important because they help explain behaviors. The variety of available methods of attitudinal research then enables the transportation planner or researcher to investigate a plethora of topics.

II -- SOME TRANSPORTATION APPLICATIONS OF ATTITUDINAL MEASURES

There have been numerous applications of attitudinal measures to transportation planning. To see the usefulness of such measures, it is helpful to first briefly examine one application.

2.1. Use of attitudinal survey to evaluate an existing service.

The setting for this study was the City of Richmond which is an urban area of moderate size and is the capital and largest city of Virginia. It has a population of approximately 300,000.

The city owns the bus system which, along with a variety of private paratransit operators, provides transportation to the public. A survey was taken to find, in general, what elements of the transport system needed most improvement. Ten characteristics of transit were of particular interest. These were:

1. bus schedules
2. ease of obtaining and understanding schedules
3. reliability of service
4. cost of fare
5. availability of schedule
6. comfort
7. safety
8. courtesy of driver
9. nearness of stop to respondent's home
10. transfer system

Of particular interest was the satisfaction (or dissatisfaction) of current bus riders with each of these attributes. To measure this satisfaction, a statistically representative sample of residents was interviewed and from that a subsample of transit users was selected.

Each respondent was asked a set of questions about his satisfaction with each transit characteristic. These questions are presented in Figure 2.1. Respondents were asked to respond by circling a number from 2 to 6, 2 corresponding to excellent and 6 corresponding to bad.

The distribution of ratings for each characteristic is presented in Table 2.1. These responses provide an indication of the feelings of the group as a whole. Overall, most users are satisfied with the service they receive. The bus seems to be safe, clean and comfortable.

There is an indication of some dissatisfaction with the reliability of the bus, the schedule and transfer system. These are frequent areas of dissatisfaction for many transit users and these responses indicate that this operator needs to spend more time reviewing these areas. More attention to on-time service and a more highly coordinated schedule will better serve these users. However, there is most dissatisfaction with the cost.

To recommend specific actions, a follow-up study should be initiated that would focus on the service attributes highlighted previously. If no effective change in fares can be implemented, then an advertising campaign should be started to point out that the price of the bus compares favorably with the price of other competing modes.

To get a better understanding of how these subjects view transit, the subjects are grouped by their viewpoints, using a more complex method of analysis of these same satisfactions questions. Improvements can be made for each of these groups. This technique will be discussed in Chapter 6.

Figure 2.1 SURVEY QUESTIONS FOR RICHMOND STUDY

Part V: Bus Service

Interviewer: We are interested in getting as many responses as possible, so although someone has not ridden the bus, they might know something about the service. Ask them questions anyway.

We would like to continue by getting your responses to questions on the bus service that is available to Richmond residents, even if you don't use it, how would you rate the local service on the following things?

V1	Schedule of bus times	[ ]	23
V2	Obtaining and understanding bus schedule information	[ ]	24
V3	Reliability (bus is not too late or too early)	[ ]	25
V4	Cost of fare	[ ]	26
V5	Cleanliness of bus	[ ]	27
V6	Comfort on bus	[ ]	28
V7	Safety on bus	[ ]	29
V8	Courtesy of bus driver	[ ]	30
V9	Nearness of stop to your home	[ ]	31
V10	Transfer system (connections are made on time)	[ ]	32

V11 About how many blocks is your home from the nearest bus stop that you use or could use?

1 not applicable	3 2 blocks	5 4 blocks	7 blocks	9 don't know
2 1 block or less	4 3 blocks	6 5 blocks	8 7 blocks or more	[ ] 33

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Table 2.1

Attitudes of Bus Users Towards Transit, Richmond Study

Transit Characteristics	Excellent	Good	Fair	Poor	Responses Bad	NR
1. Bus Schedule	9	32	28	13	3	0
2. Understanding and Obtaining Schedule	6	52	20	5	2	0
3. Reliability	8	33	31	7	6	0
4. Cost (Fare)	3	19	30	17	16	0
5. Cleanliness of Bus	5	49	25	5	1	0
6. Comfort	6	54	21	1	3	0
7. Safety	9	56	19	1	0	0
8. Courtesy	16	50	17	2	0	0
9. Nearness of Stop to Your Home	18	46	11	9	1	0
10. Transfer System	6	37	27	10	4	1

2.2. The application of these techniques to transportation.

The wide variety of transport applications of these techniques demonstrates their flexibility. There are numerous examples of the application of attitudinal and perception measures in transportation. A partial list of studies by mode is presented in Table 1 of Appendix A.

Applications have been made for virtually every mode. By far, the most applications have been made in studying mode choice between bus and car, but studies also have been undertaken in each of the following areas:

- transit planning
- highway planning
- paratransit planning
  - dial-a-ride planning
  - taxi policy analysis
  - shared ride market research
- planning of transportation for the handicapped
- railroad passenger transportation market research
- airline passenger market research
- automobile innovations policy research
- freight carrier transportation
- regulatory policy evaluation

2.3. Frequently studied elements of transportation systems

Most transport studies break down a transport system into its elements or characteristics. Subjects are then asked to evaluate or compare these characteristics on the basis of some appropriate criterion. The characteristics that are most often studied (especially in public transportation studies) are tabulated by study in Table 2 of Appendix A. This approach is often referred to as multi-attribute decision analysis.

Although many characteristics can be studied, those that are of most interest to planners and managers of transport systems are cost, intangible, difficult-to-measure characteristics is most easily measured by using attitudes. Objective measures of comfort, convenience and aesthetics are not generally available. Subjective measures are the best indicators when these characteristics are of concern.

Costs can be broken down into various elements. For example, costs of driving a private automobile can be divided into out-of-pocket costs such as gasoline, parking, tolls and fixed-costs such as purchase price, insurance and maintenance. From this breakdown, it has been found that out-of-pocket costs are most important.

Travel time has been divided into the time it takes to complete each part of trip. For the bus this typically consists of time spent in walking to the bus stop, waiting, traveling on the bus, transferring, and walking to the destination. Of these times, waiting and transfer time are most important.

Table A.2 provides an overview of which characteristics have been studied most frequently. However, the characteristics that should be studied should reflect those for which some system modification is possible. These are decision variables. Before starting any survey, the decision variables should be outlined first, then the survey questions developed and subjects selected. A brief review of survey research procedures is presented in Chapter 4.

References for Chapter 2.

Lalita Sen and Julian Benjamin, (1979), Travel Behavior and Market Segmentation of Low and Middle-Income Residents of Richmond, Va., United States Department of Transportation, Report No. DOT/RSPA/DPB-50/79/40.

III -- A CONCEPTUAL FRAMEWORK OF THE CONSUMER DECISION-MAKING PROCESS

Transportation researchers are interested in analyzing and forecasting behaviors. While it is possible to study behaviors directly, a thorough understanding of them depends on an understanding of the process by which decisions are made. It is within this context that the influence of attitudes, beliefs or opinions is important.

3.1. A consumer decision-making model

A consumer decision-making model describes the inter-relationship of various factors which influence behaviors. Before attitudes can be analyzed, their role in the decision-making process must be outlined as part of a conceptual model. The model explains the inter-relationship between a person's background and life experience, his stable beliefs (values), his attitudes towards his immediate environment and his intention to act which, when modified by environmental constraints, is translated into observable behavior. These elements of a decision model are outlined in Figure 3.1. The solid lines in the diagram indicate directions of major influence.

3.2. Life experiences and personal attitudes

Personal attitudes are influenced by life experiences. Background and environmental variables reflect the experiences of an individual and these influence the formation of attitudes. In Table 3.1 a partial list of influential background variables is listed. These variables can be classified into major groups according to their function.

Figure 3.1

ELEMENTS OF DECISION MODEL

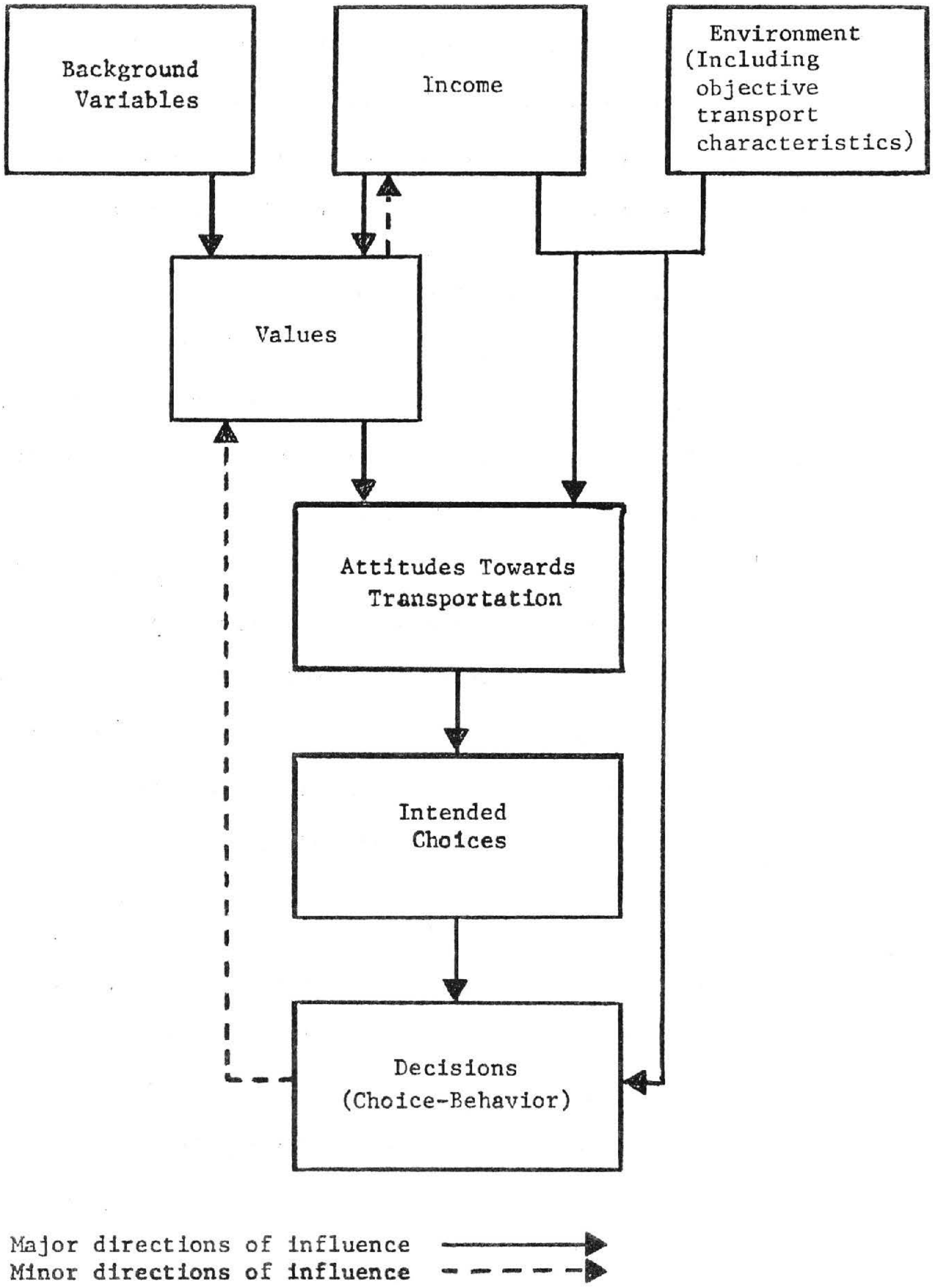

Table 3.1

Partial List of Background Variables

Socio-Economic
- Income
- Education
- Occupation
- Same of parents and spouse

Familial
- Family Size
- Family Life Cycle
- Family Life Style
- Family Members who are licensed and/or own automobile

Personal
- Sex
- Age
- Marital Status
- Preferred activity patterns

3.2.1. The significance of socio-economic variables. Socio-economic variables are variables that indicate the social class and income of an individual. Social class influences behavior by providing examples to class members as well as by applying peer pressure to accede to social norms. Furthermore, social class is linked to income and available spending money, which through budget constraints also influence behavior.

3.2.2. The significance of demographics. Demographics describe personal and familiar characteristics. Many behaviors are an expection or a necessity. These behaviors are based on age, race, sex, family size and life cycle. Family life cycle is a composite variable that reflects the number of people in a family, their roles, and their ages. Family life cycle influences transportation behaviors by influencing necessary actions of a family (e.g. school-aged children must go to school).

3.2.3. The significance of environmental factors. Environmental factors provide both experiences and constraints. Environment consists of the city, area of the city and neighborhood characteristics. Neighbors provide exemplary behaviors and peer pressure to conform. At the same time the transportation opportunities, that is -- available facilities and services, act as a constraint. Thus, if a person lives in a neighborhood with good transit facilities, a high percentage of commuters will take transit and taking the bus will seem acceptable.

3.3. Personal values

The most stable attitudes are values. Personal values may last a lifetime. They consist of personal attitudes such as political conservatism (vs liberalism), family orientation (vs independence) and a love of aesthetics. These are just a few of the many values a person may hold. For example, an independent person may always prefer car to transit. Furthermore, because values are stable, they are difficult to influence and must usually be viewed as a given constraint by planners.

These values are influenced by life experiences. They in turn influence attitudes toward daily occurrences. A list of values that influence transportation decisions is presented in Table 3.2.

3.4. The concept of utility.

The utility of each choice determines intended behaviors. Of the feasible alternatives, consumers will choose the alternative transportation system that provides the highest utility. Utility is a measure of the satisfaction a consumer receives from a product (or service). Utility is a function of the partial utilities of each characteristic of system (or facility).

It therefore becomes necessary to describe a system as a set of attributes. With a knowledge of the part-utility of each important attribute, the overall utility can be calculated as some combination of these part-utilties. In analyzing utilities, complete knowledge of the combination rule to form the overall utilities is essential. This will be discussed in Chapter 8.

The most widely used models of utility formation state that consumers combine part-utilities by summing them. Known as compensatory models, they state that a sufficient amount of any characteristic can compensate for a deficiency in another. For example, with sufficient monetary incentive, a person can be pursuaded to walk extra distances and take the bus.

The compensatory models are typified by linear additive functions. Polynomial and ideal-point functions also permit equivalent compensation between attributes.

In a linear-additive model, overall utility is the sum of the part-worth or part-utility of each transport attribute. In an ideal-point model, overall utility is a function of the proximity of transport alternatives to an ideal transport mode. For example, the lower the cost the more preferable a mode is - to a point. Many people prefer to pay a fair price for transit but do not wish to ride for free.

Polynomial functions assume that the effect of two factors taken together is greater than the sum of the part utilities of each attribute taken separately. In other words, instead of adding part-utilities, these models form overall utility as the result of multiplication of the part-utilities.

This can be illustrated by an example. Low cost transit and express bus are both more attractive than conventional local bus service. Together, a low cost express bus may be much more attractive than a service which has either characteristic taken separately.

Despite their widespread use and applicability, compensatory models are inadequate where the lack of a factor is critical. For

Table 3.2

Personal Values that May Influence Transportation Decisions

Aesthetics

Personal Leisure and Recreation

Environmental Concern

Political Conservatism

Economic Concern

Privacy

Independence

Social Status

example, for a person confined to a wheelchair, a bus without a wheelchair lift is inaccessible and cannot be compensated for by any amount of money.

Other decision models handle decisions as the result of constraints on choices. Heirarchical models apply where each decision is taken separately, attribute by attribute. In heirarchical models, decisions are based on the level of highest utility on the most important attribute, then the second most important attribute and so on until all attributes have been considered.

A variation of the heirarchical model is the satisfying model, where a minimum satisfactory level must be reached on each attribute of an alternative for that alternative to be included in the "choice set". However, these models have been used infrequently.

The characteristics that have been studies most frequently are listed in Chapter 8. With a knowledge of the most attractive (highest utility) choices, choice behavior can then be forecasted.

3.5. Summary

* In summary, consumer decisions result from the background and attitudes of each consumer
* Actions result from decisions
* Decisions are a result of the utility of each alternative and the consumer's desire to maximize utility
* Overall utility is a combination of the part utility of each characteristic of a service
* Utility results from the values, needs and background of the individual

3.6. Personal activities and transport decisions.

Transportation decisions are complex decisions which result from decisions to participate in activities or to move goods. The discussion in the preceding sections must be understood with the knowledge that transportation is a secondary commodity, purchased to enable the consumer to get where he wants or to obtain the products that he wants. First the consumer of personal transportation must decide the activity(ies) in which he wants to participate. Trips may be to work, to go to school, recreation, shopping, to go for a medical examination, to take part in a religious observance or some other activity. The individual must also decide the time, location, mode and route to his destination. Although he may not decide this explicitly in this order, the decisions are implicit in his decision to travel. Complicating this process is the need to chain compatible trips together. Another often over-looked decision is the location of his home, which is also a function of transportation. Because of the complexity of trip-making decisions, the researcher must carefully define his research questions to effectively answer his research problems.

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IV -- A BRIEF REVIEW OF SURVEY RESEARCH BASICS

Before initiating a study, the planner/researcher should review survey research methods. A set of general steps for survey research is presented in this chapter.

1. Carefully define the problem.

The first task is to define the research problem. What needs improvement? How can the system best be improved? Who will use it? What will indicate success or failure?

2. Decide who should be interviewed and how they should be sampled.

Referred to as the population, these are all the people you are interested in knowing about. They may be described by location, place of work, age, income, race, activity or some other criterion.

3. Decide what information is needed.

Find what information about these people will best solve your problem. The information you gather should be limited to indications of consumer response to specific systems changes under consideration. This information should be identified within the context of the behavioral model discussed in the previous chapter.

4. Select the appropriate attitudinal measurement approach.

When measuring attitudes, select the approach that will most effectively measure the attitudes of interest. An approach consists of a set of questions as well as a method of analysis. A variety of approaches will be reviewed in the next chapter. The analytical method should always be considered while developing questions.

When considering approaches, the cost of the approach should also be considered. The cost is made up of the cost of administering and analyzing the responses. Administrative costs are related to the format for the questions. There are basically 3 questionnaire formats:

* <u>Telephone</u> - This is inexpensive, but is generally limited to 5 minutes of questions and the questions must be of relative simplicity. Also, the sample is biased to people who have their own phone.

* <u>Mail</u> - This format permits more lengthy surveys but is limited in what tasks can be performed. An additional problem is a traditionally low response rate.

* <u>Personal interview</u> - This format permits a wide range of questions of substantial length. The usual time limitation is 1/2 hours, although longer questionnaires are possible.

  The costs here can be prohibitive. Costs will be related to the time it takes to administer the questionnaire and the geographical dispersion of residents.

To a great extent, format will depend on the nature of the questionnaire. Different formats can also be used together. For example, to interview handicapped persons, a two-step procedure can be used. First, screen respondents by telephone, then follow-up with a personal interview.

5. <u>Code data and check for accuracy.</u>

Data should be coded suitably for analysis and the coding should be double-checked.

6. Analyze responses using appropriate measurement and analysis techniques.

Techniques used should be consistent with the responses and sampling design and should be focused on solving the planning, marketing or design questions which are the focus of the study.

7. Summarize results with recommendations for decisions.

Presentation of results should clearly indicate the planning or other transport systems implications of the research.

The references at the end of this chapter provides a more thorough discussion of survey design. Each element mentioned here should be referred to while reviewing the various methods that are presented in the next chapters.

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V -- A TAXONOMY OF ATTITUDINAL MEASUREMENT APPROACHES

Approaches to attitudinal measurement date back to the work of Thurstone in the 1920's. The variety of approaches were developed from different research objectives.

The various approaches listed here differ in several ways:

* Some methods can analyze general factors such as cost or service quality; other methods measure responses to specific levels of a variable such as bus fare equal to fifty cents.

* Some methods analyze results for a cross-section of subjects; other methods analyze responses for one subject at a time.

* Some methods assume that primary data is rank order data; other methods assume that primary data is interval scaled.

* Each method analyzes data consistent with these assumptions.

* Each method has its own assumptions about the underlying functional form. Although most analytical techniques assume a linear additive functional form, some techniques do not. In some techniques i is possible to test different functional forms.

  Some methods analyze one variable at a time; most techniques analyze attitudes towards all variables at the same time.

  Some methods analyze attitudes towards transportation systems or system attributes with respect to preferences or intention to use the system; others use evaluative criteria such as satisfaction or importance.

The form of the questions and the questionnaire, the topic of the questions, the information that can be obtained and cost of administering it all depend on the technique that is selected. There are four categories of scaling techniques. Within each category there are a variety of techniques and applications. The categories are unidimensional scaling, multidimensional scaling, conjoint measurement and functional analysis.

5.1. Scales used for each technique.

A variety of scales can be used with each technique. Each technique results in a relative measure on which some set of items is compared. These items (or stimuli) may be some transport characteristic or they may represent a transport mode or transport system.

Each item ultimately is assigned a rating on some scale. The scale is a yardstick that indicates the relative intensity of feeling a subject (or subjects) have toward each item.

Frequently used scales include personal preference, importance in making a decision, agreement with a statement and satisfaction with existing services.

5.2. Unidimensional scales.

Unidimensional scaling compares items on one scale at a time. These techniques measure attitudes towards one variable at a time. Scales are formed in a manner that enables comparisons between attitudes to different transportation characteristics.

For most techniques, all transportation characteristics are compared on the same scale. Respondents are then asked to rate each item according to his assessment of his feelings about that item.

Four scales have been used most frequently:

* Personal preference
* Importance in making a decision
* Agreement or disagreement with a statement about transportation
* Satisfaction with existing service or facility

Three unidimensional scaling techniques are widely used; they are Thurstone Scales, Categorical Scales and Osgood's Semantic Differential. These are discussed in Chapter 6.

5.3. Multidimensional scales.

Multidimensional Scales find rating on several different scales at the same time. These techniques measure attitudes towards several items at the same time and on one or more different, and unrelated scales simultaneously. These techniques can be used to analyze attitudes towards transport characteristics (i.e. speed, cost) and some of these techniques can also be applied to complex stimuli such as modes of transportation, vehicles or facilities.

There are four kinds of multidimensional scaling techniques that are frequently used: structural analysis, similarities scales, external analysis of preference data and internal analysis of preference data. These are presented in Chapter 7.

5.4. Conjoint measurement.

Conjoint measurement is used to find the contributing elements to the overall preference for complex stimuli. This technique finds the contribution of specific levels of a factor (or transportation characteristic) to the overall attractiveness of a stimulus (transportation facility or service). For example, what levels of cost and travel time make a mode most attractive?

Data consist of preference comparisons between items. Preference rankings may also be used. This is discussed in Chapter 8. Tradeoff analysis is similar to conjoint measurement but it analyzes responses to stimuli made from two factors at a time. This is also discussed in Chapter 8.

5.5. Functional analysis.

Functional analysis is conjoint measurement using preference ratings. This technique is similar to conjoint measurement; the difference is that preference ratings are obtained instead of comparisons or rankings. Responses are considered interval scaled, It not only becomes the task of the subject to indicate which items he most prefers but to also indicate the intensity of that preference.

The difference in the assumptions about the quality of the data leads to different analytical techniques. Since measures are interval scaled at the start, conventional statistical techniques such as analysis of variance can be used (under appropriate assumptions about the probability distribution of error terms). This is discussed in Chapter 9.

5.6. Other approaches to scaling preferences

Other techniques are under development that concern decision processes:

* There are approaches that assume an ideal point model with a modified conjoint data set.
* Linear program estimation techniques are being developed.
* Cross-sectional techniques such as logit analysis have been used with attitudinal data.
* Approaches that assume heirarchical, lexicographic or satisfying decision models are being investigated.

In Chapter 10 at the end of this manual, Table 10.1 presents a comparison of the six techniques with respect to 16 characteristics of the techniques. In general there is a tradeoff between the degree of detail in the information gathered and the expense of the technique.

VI -- ONE CHARACTERISTIC AT A TIME -- UNIDIMENSIONAL SCALES

Unidimensional scales measure attitudes towards one transportation attribute at a time on one scale. There are three approaches that are discussed here. Each approach has a different purpose; they are compared briefly in Chapter 5.

6.1. Thurstone scales.

Thurstone scales compare intensity of opinion on a particular scale. Differences in intensity are a function of the number of times one item is determined to be more highly evaluated than another. In market research, this has most frequently been used to evaluate personal preferences for products.

To use Thurstone scales, data requirements include:

* Question format -- either a complete set of paired comparisons or, under transitivity assumptions, a rank order of items.

* Possible scale -- preference, importance, satisfaction

* Transportation applications -- general attitudes towards transportation characteristics such as:
  - cost
  - travel time
  - comfort
  - convenience
  - waiting time

To use this technique, use a format similar to the following illustrative example:

> Instructions - Please rank each of the following transportation attributes according to its importance in selecting a mode of transportation by placing 1 next to the attribute that is most important, 2 next to the second most important and so-on until all transport

attributes have been ranked. Be sure that all attributes have been ranked and that you have not used the same number twice.

Attribute	Importance Ranking
cost	________
comfort	________
travel time	________
.	.
.	.
.	.

Analysis of responses is cross-sectional and is described in detail by Thurstone (1929), Torgersen (1955) and Green and Tull (1974).

6.2. Categorical scales.

Categorical scales require subjects to evaluate transport characteristics one at a time. These scales are the most frequently used. Respondents are asked to rate each charactistic separately, usually on the same five-point or seven-point scale. When an overall rating is desired for a compound attribute (such as satisfaction with a transit mode), the attributes ratings are added together for any subject. Results can also be analyzed across subjects identifying the median response or using other percentile measures.

To use categorical scales, data requirements include:

* Question format -- A series of transport characteristics each evaluated on the same 5 point 7 point or 9 point scale. The preparation of scales should imply equal spacing between points. Each point can be labeled individually (e.g. extremely satisfied, very satisfied, satisfied, not satisfied, not satisfied at all) or selected or extreme points can be labelled (e.g. very satisfied to not satisfied at all). Generally, 7 and 9 point scales are labelled at the extremities while 5 point scales can each be labelled individually.
* Possible scales -- importance, satisfaction, agreement (with statements about characteristics or situations).

* Transportation applications -- evaluation of existing facility or service characteristics, market potential of new systems characteristics or evaluation of community values, goals and objectives.
  - Example of service characteristics that can be used with this technique are the same as the preceeding technique.
  - Example of statements used to measure values, goals and objectives are:

    I enjoy low cost transit.

    I like to ride on vehicles with people like myself.

    Our community should spend more to improve public transit.

  - Subjects would be asked about the degree of agreement or disagreement with these statements.

To use these scales a format is required similar to the following ilustrative example:

Instructions - Please rate each of the following transit characteristics according to their importance in selecting a mode of transportation by circling the number that best respresents your opinion.

Transit Characteristic	Very Important						Not Important
cost	1	2	3	4	5	6	7
travel	1	2	3	4	5	6	7
comfort	1	2	3	4	5	6	7
waiting time	1	2	3	4	5	6	7

Discussion of the analysis and use of these responses is found in Torgerson (1955) and Green and Tull (1974). Direct application of this techniques to public transportation found in Dobson and Golob (1972), Sen and Benjamin (1979), Orange County (1978) and Systan Inc. (1980).

6.3. Semantic differential scale.

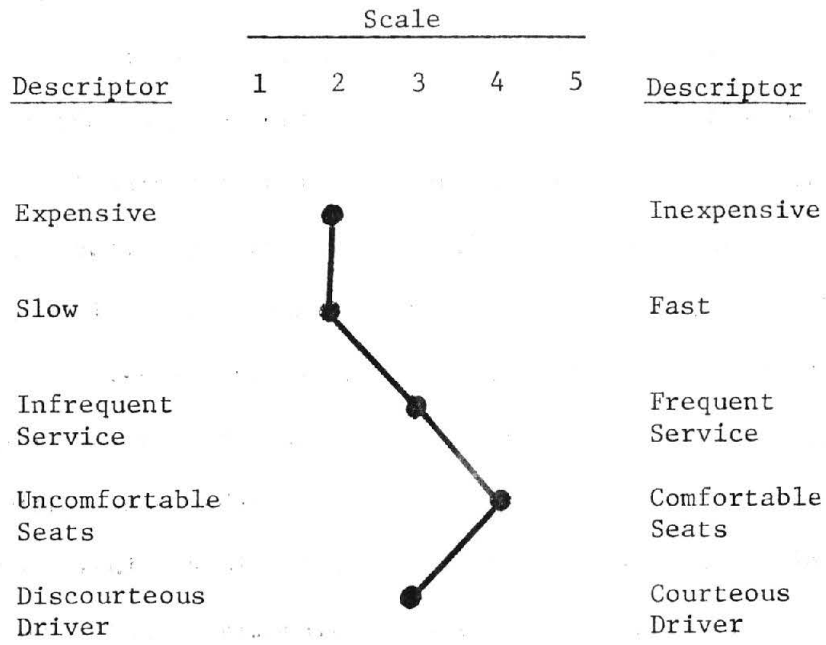
Semantic differential scales allow subjects to evaluate transport facility and service characteristics on separate scales.

These scales are bi-polar scales that use opposing adjectives or descriptors to describe and evaluate each characteristic. For example, to evaluate transit fares, you might describe transit as expensive versus inexpensive. The evaluation on this scale by a subject specifically indicates the evaluation of the subject of that characteristic. From this response, relative satisfactions can be implied. In comparison, when for example, cost of transit is evaluated on satisfaction scales, a response of dissatisfaction does not specifically indicate an evaluation of cost alone. The question still remains, is the cost too high, too low or does any price seem too much for the available service? On the other hand, although a response of "expensive" on a semantic scale clearly indicates the source of dissatisfaction, it does not directly indicate whether the level of expense is so high that it affects choice of mode. Each scale asks for specific responses which should be tailored to answer specific research questions.

Responses can be analyzed cross-sectionally using frequency distributions and percentiles. Graphical representations are particularly useful. One graph technique presents median responses, attribute by attribute. The medians are connected for easy comparison and the corresponding opposing descriptors are listed on the left and right margins of the graph to label each point. This is illustrated in Figure 6.1.

Figure 6.1

A GRAPHIC ANALYSIS OF MEDIAN
SEMANTIC DIFFERENTIAL RESPONSES*



*Entries are median responses for each transport attribute.

To use semantic differential scales, data requirements include:

* Question format -- a series of 5, 7 or 9 point scales, each scale described by opposing adjectives. The presentation of scales should imply equal spacing, with an extreme descriptor at either end.

* Possible scales -- scales can be any relevant transport characteristic which can be described by opposing adjectives (i.e., cost, comfort, reliability, speed). There is difficulty in using this approach to evaluate specific levels of characteristics or characteristics that are best described by nouns (i.e. full sized bus, red color).

* Transportation applications -- evaluation of existing modes, assessment of transport choice processes, evaluation of initial response to proposed new facilities or services.

To use these scales, a format is required which is similar to the following illustrative example:

> Instructions: Each of the word pairs listed below is used to describe our local bus service. Please circle the number on each line that best represents your feelings about the bus service. After you finish, please check to be sure you have answered all parts of this question.

inexpensive	1	2	3	4	5	6	7	expensive
slow	1	2	3	4	5	6	7	fast
comfortable	1	2	3	4	5	6	7	uncomfortable
.					.			.
.					.			.
.					.			.

The use of unidimensional scales is illustrated in the introductory example in Chapter 2. In that chapter there is a completed study using categorical-type satisfactions scales including analysis and application of responses.

Standard statistical packages such as SPSS (Nil, et al. 1975) can be used to calculate median responses or mean responses under ratio or interval scale assumptions.

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VII -- MULTIDIMENSIONAL SCALING: ALL ATTRIBUTES TOGETHER

The underlying idea behind multidimensional scaling is that items are not evaluated on one scale alone but rather on a set of unrelated scales. Although the data requirements are similar for many unidimensional and multidimensional methods, the results of the analysis are quite different. For example, using these techniques, items ranked by preference will result in a set of composite measures on different, unrelated scales. These scales can often be identified as cost and quality of service.

Four multidimensional techniques will be discussed here:

1. Principal Components Analysis
2. Similarities scales
3. External analysis of preferences
4. Internal analysis of preferences

7.1. Principal components analysis.

Principal components analysis is used to analyze several categorical scales simultaneously. Instead of resulting in placement of transportation attributes on one scale, such as satisfaction, the analysis results in placement on several uncorrelated factors. These factors are standardized and are called principal components.

Essentially, in this analysis, each characteristic rating is considered a separate variable. All ratings are intercorrelated to some extent. The analysis results in the formation of a set of new factors each of which is a linear combination of all ratings. The factors are formed so that there are especially large contributions from those ratings that are most highly correlated.

This factor represents a new composite rating that behaves essentially identically to the original correlated set of variables. The solution consists of a set of factors that are correlated with the original variables. By carefully selecting factors that explain most of the variation in the data, there are fewer factors at the end of the analysis than there are ratings at the beginning.

The SPSS, BMD, BMDP and SAS statistical packages all provide good factor analysis programs. In these programs the user is provided with several measures including a factor matrix, factor loadings and factor scores. The factor matrix is the set of the coefficients for each of the variables on each factor; the factor loadings indicate the correlations between factors and original variables and the factor scores represent subject by subject values on the reduced set of factors. These can be used in subsequent analysis. In addition, a set of eigenvalues can be used as a guide to the inclusion of a factor in a solution. As a rule of thumb, all factors with eigenvalue greater than one should be used.

7.2. Similarities scales.

Similarities scales are similar in principle to principal components but are capable of analyzing multi-dimensional attitudes for individual subjects. In this approach, subjects are asked to evaluate the similarity between items. The items may be simple transport attributes such as cost or comfort or complex stimuli such as modes of transportation or destinations.

The result of the analysis is a set of scales on which each item is located. The items are located in a way that maintains the consistency of the euclidean distance between them (as calculated from their position on each factor) and the rank order of the similarities judgements reported by the subject. In other words, similar items end up close to each other; dissimilar items end up far apart.

In factor analysis, cross-sectional correlations are the measure of dissimilarity and the result is one set of principal components for all subjects. In similarities scales, similarities judgements may be either individual or cross-sectional and result in a set of scale values that are consistent with the rank order of the input data.

The data requirements for similarities scales are:

* Question format -- a set of item, pairs each evaluated on the same 5,7, or 9 point similarities scale. Presentation of scales should imply equal spacing and only end points need be labelled.

* Transportation applications -- determination of market potential for proposed services or facilities or their characteristics.
  - Examples of characteristics are the same as those mentioned in Chapter 6.
  - Examples of proposed new services or facilities are express bus, dial-a-ride, dual mode and high occupancy vehicle lanes.

To use these scales, a format is required that is similar to the following illustrative example:

> Instructions: Listed below are a set of pairs of transit characteristics. Please indicate whether in your opinion these pairs of characteristics are similar or different by circling the appropriate number. Use "1" if you think that they are virtually identical, "7" if they are completely different, and intermediate numbers for intermediate levels of similarity.

1st Transit Characteristic	2nd Transit Characteristic	Very similar						Very different
travel time	waiting time	1	2	3	4	5	6	7
cost	travel time	1	2	3	4	5	6	7
comfort	cost	1	2	3	4	5	6	7

Special purpose algorithms are needed to analyze this data. MDSCAL5 in the Bell Laboratories Multidimensional Scaling Package can analyze these data sets one case at a time. Individual differences between subjects can be highlighted by using the INDSCAL program which is also available in the same package. This program finds an average solution for all subjects with individual importance weights for each subject. For example, in a problem where subjects are asked to evaluate transit options, one subject might look primarily at cost but a second subject may look primarily at comfort. In an INDSCAL solution, these transit options would be measured by both cost and comfort in the common solution; however, the importance of cost would be greater for the first subject and the converse for the second subject. There is a discussion of these procedures in a market research context in Green and Ruo (1972).

7.3. External analysis of preferences.

External analysis of preferences is used to analyze preferences for transport items. These items may be either characteristics or complex stimuli such as transit services, facilities or modes. The technique finds the optimal combination of transport characteristics (or factors) for each subject. The technique requires a similarities solution which is external to the preference solution, thus it is an external analysis.

The approach in the preceeding section provides a sufficient similarities solution.

One of two of the models that were discussed in Chapter 5 are assumed here. As expected, estimates for parameters depend on the preference model that is assumed. The basic models are:

A linear model -- This model assumes that overall preference is the weighted sum of attributes (or factors). The more there is of an attribute, the higher the preference (or lower in the case of negative weights).

For example, in selecting transit, if the speed is higher, the mode is more attractive. This is illustrated in Figure 7.1.

An ideal point model -- This model assumes that overall preference is a function of the distance that an item is from an ideal combination of attributes (or factors). The ideal point is the best combination of attributes for a subject. The functional form is usually quadratic.

Following the previous example, if an ideal point model is assumed, there is an ideal speed for public transit. In other words, a subject would like a faster vehicle up to a point, where upon the speed is viewed as excessive and the attractiveness declines. This is illustrated in Figure 7.1.

To use this technique, data requirements include:

* External data -- A similarities solution (see previous section of this chapter) is needed for each subject.

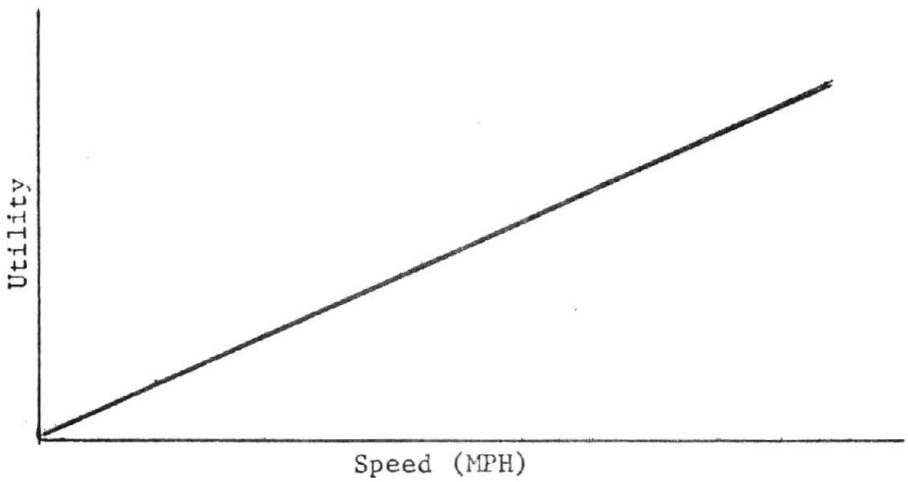
* Question format -- The set of items must be compared according to preference (or some other similar criterion). Under transitivity assumptions a preference ranking is sufficient.

* Transportation application -- Estimation of the most attractive mode, facilities or service characteristics or the development of groups of people who have similar wants and desires. This technique has also been used to analyze a variety of transportation and urban planning problems such as residential mobility.

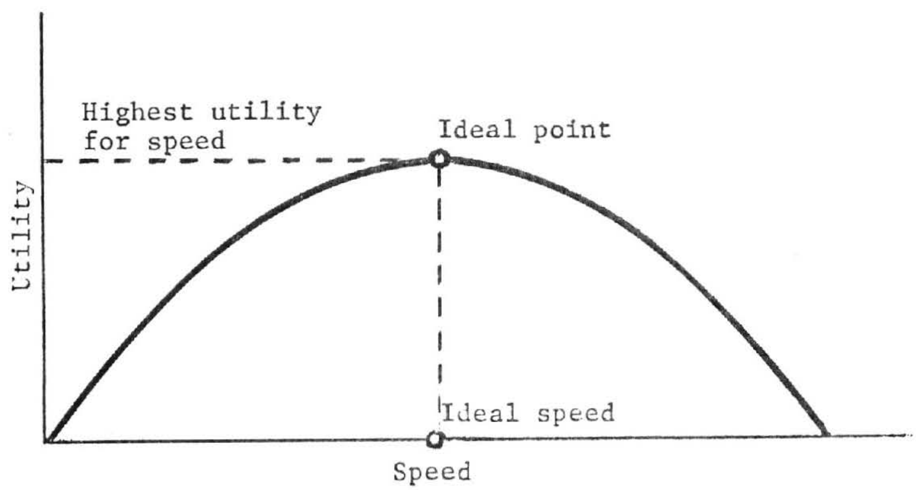
Figure 7.1

COMPENSATORY UTILITY MODELS
USED IN MULTIDIMENSIONAL SCALING

Linear Model



Ideal Point Model



To use this technique, use a question similar to the following illustrative example:

> Instructions: The following are a set of personal transport modes. Please select the mode you most prefer to use to go to work and place a "1" next to it in the space provided below. Next, place a "2" next to the mode you prefer second and continue to rank each mode until all modes have been ranked. Be sure that you use each number only once.

Mode	Rank
Bus (local)	________
express bus	________
transit	________
car	________
walk	________
.	.
.	.

The PREFMAP program in the Bell Laboratories Multidimensional Scaling Package will perform this analysis. The program includes options and comparative measures for either linear or ideal-point models for either rank order or interval scaled input. References for analysis are Carroll (1977) Green and Tull (1978) and Green and Rao (1972). These techniques were applied to mode choice by Dobson, Golob and Gustafson (1974), Dobson and Nicholaidis (1974) and to residential location by Benjamin (1977).

7.4. Internal analysis of preferences.

Internal analysis of preferences is similar to the external analysis of preference responses discussed in the preceeding section of this chapter, except that only preference rankings are used. By eliminating the need for a similarities solution, data requirements are substantially reduced. In this technique, the placement of items on a set of factors is calculated cross-sectionally from the preference rankings. Hence, one solution is found for all subjects. However, separate preference function parameters are estimated for each subject.

As in the external analysis, preference functions may be linear or ideal point. Solution is obtained in a manner similar to principal components analysis. Except for external data, data requirements, formats and applications are the same as those for the external analysis of preferences. The technique is generally more useful than the external analysis because of the reduced data requirements.

The MDPREF program in the Bell Laboratories Multidimensional Scaling Package will perform this analysis. The program assumes a linear model and finds a preference and similarities solution simultaneously. Ideal points can be found using PREFMAP along with the common space solution from MDPREF.

References for analysis are Carroll (1972), Bell Laboratories (1976), Green and Tull (1976) and Green and Rao (1972). This was applied to mode choice by Dobson (1976) and to residential location, Benjamin (1977).

7.5. An example of an application of an internal analysis

This application utilized the satisfactions responses discussed in Chapter 2 in the study by Benjamin and Sen (1979). The responses were gathered from a random sample of residents of Richmond Va. The responses analyzed here are from current users of public transit. Ten transit attributes were rated for satisfaction. These ratings were submitted to an internal analysis using MDPREF (Carroll, 1972).

A three-dimensional solution was found to explain 63% of the variation the data. The first two factors are illustrated in Figure 7.2. The factors were labelled based on the extreme position of attributes on each factor. The labels were:

1. Temporal coverage versus other service amenities.
2. High cost versus low cost
3. High service quality versus low service quality

The arrow heads in Figure 7.2 indicate directions of highest satisfaction. The rank order of satisfaction ratings is identical to the ranking of the projections of attributes on a line drawn from the arrow head through the origin for each subject.

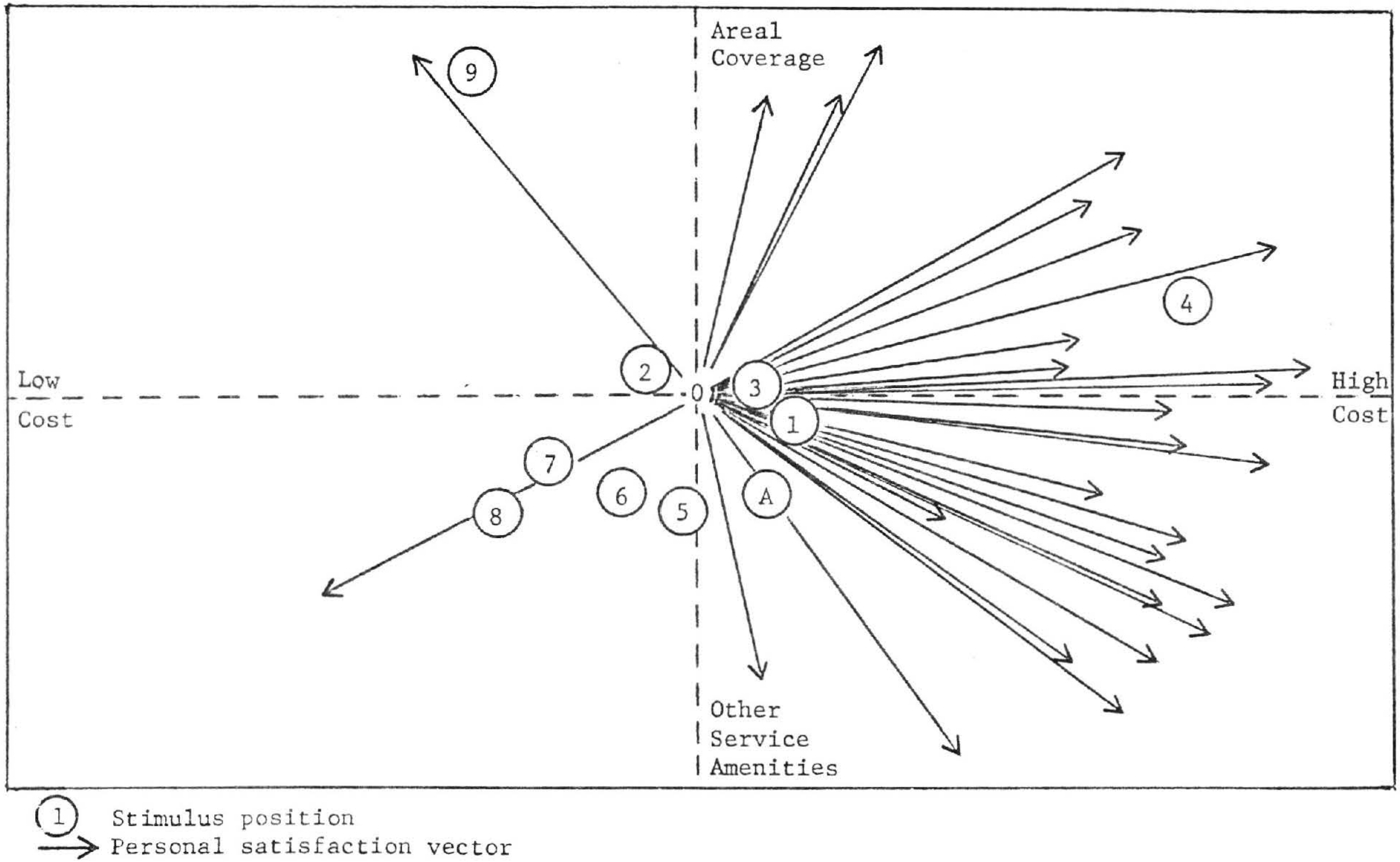
Inspection of the graph indicates that no one is satisfied with cost and that those satisfied with service amenities (courtesy of driver, etc.) are dissatisfied with areal coverage (proximity to bus stop) and visa versa.

This result would lead to separate marketing strategies for subjects with different satisfactions and an overall strategy to deal with the problems of cost.

The advantages of the technique is that it differentiated multivariate patterns. Analyzed cross-sectionally, as in Chapter 6, tradeoffs between service amenities and areal coverage would not have been discovered. As a next step, market segments can be identified systematically using clustering algorithms. This will be discussed in Chapter 10.

Figure 7.2

MULTIDIMENSIONAL SOLUTION
USING VECTOR MODEL OF
DISSATISFACTION OF RICHMOND SUBJECTS



Attribute Labels

1. Schedule of bus times
2. Obtaining and understanding bus information
3. Reliability
4. Cost of fare
5. Cleanliness of bus
6. Comfort on bus
7. Safety on bus
8. Courtesy of bus driver
9. Nearness of stop to your home

A. Transfer system

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Multidimensional Scaling

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VIII — CONJOINT MEASUREMENT: AN ANALYSIS OF INDIVIDUAL PREFERENCES

Conjoint measurement is used to find the partial contribution of specific levels of transport characteristics to the overall attractiveness of a transport mode, service or facility. Most conjoint models assume a linear preference function. It is assumed that the preference for an item is the weighted sum of preferences for each of the factors that describe it. This model is derived from concepts in micro-economics (there it is expressed as utility theory) and from concepts in social psychology and is discussed in Chapter 3.

As discussed in Chapter 5, the resulting measures (referred to as part-utilities) indicate the salience of a specific levels of attributes. For example, conjoint measurement could find that most people are willing to pay 50 cents for a local bus and 75 cents for express service. This ability to analyze reactions to specific changes enables application to a wide variety of real planning problems.

8.1. Conjoint measurement.

Conjoint measurement is similar to regression analysis. The method is essentially a regression analysis that estimates beta coefficients based on only the rank order of the responses (an analysis of the rank order of responses is known as a non-metric analysis). As in regression analysis, preference (or some similar measure) is the dependent variable and dummy variables representing the levels of each factor are the independent variables.

Data requirements consist of a preference ranking of a set of proposed or imagined items (transportation modes, services or facilities). Each item is described by a comparable set of factors.

Figure 8.1

FULL-FACTORIAL DESIGN FOR THREE FACTORS, TWO LEVELS EACH

Item Number	Factor I Level		Factor II Level		Factor III Level	
	1	2	1	2	1	2
1	X		X		X	
2	X		X			X
3	X			X	X	
4	X			X		X
5		X	X		X	
6		X	X			X
7		X		X	X	
8		X		X		X

Figure 8.2

LATIN SQUARE DESIGN
THREE FACTORS, THREE LEVELS EACH

Factor I
Three Levels

		1	2	3
Factor II	1	A	B	C
Levels	2	B	C	A
	3	C	A	B

Entries in table indicate factors and levels of Factor III as follows:

Level 1 - A
Level 2 - B
Level 3 - C

The items must be formed systematically so that there is sufficient information to estimate all desired part-utilities. The complete set of items must be formed from a balanced set of levels and factors so that part-utility estimates are unbiased.

While the selection of factors and factor levels can present some difficulties, items can be formed by the following process. The process must consider existing items as well as those that are proposed. Decide what factors or characteristics best distinguish proposed and existing items. In public transit these are usually cost, travel time and frequency.

List the set of factors and the existing and proposed levels. Add additional levels in between these levels or extreme values to test extreme cases. Try to limit the number of levels and factors.

8.2. Design of experiments.

Combinations of factors are similar to experimental designs. A full set of items (known as a full-factorial design, drawing on an analogy with design of experiments) consists of all permutations of each factor level with every level of every other factor.

For two factors of two levels each, there would be 2 X 2 = 4 possible items:

Factor I		Factor II	
Level I	Level 2	Level 1	Level 2
X		X	
X			X
	X	X	

For three factors of two levels each, the number of possible items quickly increases to 2x2A = 8. This is illustrated in Figure

8.1. For three factors of four levels each there are 4x4x4 = 64 items in a full factorial design. Needless to say, even this relatively simple problem presents an unreasonable ranking task for a subject.

The answer to this problem is to use a design with a smaller number of items. This is referred to as a partial factorial design. There are many ways to reduce the difficulties of ranking items composed of multiple factors and levels. A review of a text on design of experiments can give the researcher many ideas. Any design must be balanced with respect to the number of times a factor level appears with any other factor level.

Two designs will be discussed here; they are Latin square design and block designs.

8.2.1. Latin square design. Latin square designs are balanced partial factorial designs for three factors, where each factor has the same number of levels. These designs are devised so that each level of each factor is combined with each level of the other factors one time. A 3 x 3 Latin square design is illustrated in Figure 8.2. The full factorial design in this case has 3 x 3 x 3 = 27 items but the Latin square has only 3 x 3 = 9 items.

It is possible to develop Three completely different Latin squares from factors with three levels each. These three Latin squares together make up the full factorial design. In general there are as many different Latin squares in a complete set as there are levels in each factor.

While there is a great advantage in the reduction of the number of items, this is accompanied by a reduction in the amount of information obtained. With a Latin square, only linear models can be estimated for individual subjects.

Other designs permit the use of additional factors. Greco-Latin squares are made by superimposing two separate Latin-squares with the same first two factors and with different third factors. This creates a balanced design with an additional factor. Other balanced designs can be formed from factors with unequal number of levels.

8.2.2. Block designs. Block designs are partial factorial designs that include a reduced number of factors in a series of separate full factorial designs. A four factor design can be replaced by four, 3-factor designs. If the factors are cost, travel time, frequency and bus size, new separate designs would be formed as follows:

cost, travel time, frequency

cost, freuqency, bus size

travel time, frequency, bus size

cost, travel time, bus size

From these same factors it is possible to form 6, 2-factor designs:

cost, travel time

cost, frequency

cost, bus size

travel time, frequency

travel time, bus size

frequency, bus size

These two factor designs are used in tradeoff analyses.

The advantages of block designs are:

- Each block contains a reduced set of items in each block
- Each item is composed of a reduced set of attributes, making comparisons easier.

There are some disadvantages:

- The total number of comparisons for all blocks together actually increases
- There is a loss of information about high order interactions (effects of several variables together).

It is possible to use partial designs within each block and to eliminate selected blocks from the overall design. By using balanced and block design together, it is possible to gather information on a large number of factors efficiently.

8.3. Questionnaire format for conjoint measurements.

Conjoint measurement questionnaires must be formed carefully. There are special analytical programs available for both conjoint measurement and tradeoff analysis. They are available for both multiplicative and linear models. (They are listed in a later section of this chapter). To use conjoint measurement, data requirements include:

* Question format -- a series of items, carefully and systematically described by a set of comparable factors. The items are listed and next to each is provided a space for the preference ranking.
  A modified version of this provides for a rating scale with equally spaced numbers from "1" least preferred to "9" or "11" most preferred. Only extremities need to be labelled.
  For tradeoff analysis, an alternate format is a presentation of matrices with each matrix made up of rows and columns defined by the levels of factor pair. Another format used for tradeoff analysis consists of paired comparisons of key elements of each of the tradeoff matrices.

* Possible scales -- preference, intention to use item or subjective likelihood of choice.

* Transportation applications -- analysis of mode choice or other choice processes, market segmentation or analysis of transportation policy options.

To use these scales, a format is required similar to the following illustrative example:

This example is based on an examination of bus service changes. Two factors are considered: bus fare and travel time. The levels are are:

* bus fare - free, $ .50, $1.00

* travel time (minutes) - 10, 15, 20

Instructions - Consider the options for bus service that are listed below. Each service is described by a bus fare and travel time. The bus fare is for a one-way trip. The travel time is the time it takes from the moment you enter the bus until you depart.

We would like to know your opinion about which service you would most prefer for your daily trip to work. Select the service you most prefer and place "1" next to it. Then place "2" next to your second preference and continue until all services have been ranked. Be sure to use a number only once.

Service		Preference Ranking
*Bus fare (dollars)	Travel time (minutes)	
Free	10	________
$ 1.00	20	________
.50	10	________
.	.	.
.	.	.
.	.	.

* Presentation should be randomized to minimized influence of presentation on responses.

Conjoint measurement data can be analyzed by the MONANOVA program of the Bell Laboratories multi-dimensional scaling package. Analysis of trade-off data can be done by MONANOVA or by the trade-off analysis computer package available from New York State Department of Transportation (Donelly, Howe and Deschamps (1976).

8.4. An application of conjoint measurement.

An example of an application of conjoint measurement is a study of mode choice in Charlotte, North Carolina. As an example of the application, results are presented from a study that was performed to evaluate the introduction of express bus service on one route in Charlotte, North Carolina. This study was of particular interest because of the variety of techniques employed. A more detailed description of the study is presented by Benjamin and Sen (1980). The same study will be referred to in Chapter 9.

Three zones were chosen from which the sample was selected. The first zone was the new service route and is referred to as the experimental zone. The others, zone 1 and 2, were selected as controls.

The different zones are located on a map in Figure 8.3. The samples consisted of 100 subjects in each zone. Subjects were selected who commuted each day to work downtown. The discussion here will focus on the survey carried out in the experimental zone.

8.4.1. The survey instrument was designed so that consumer response to future systems changes could be analyzed. The factors chosen for this research were factors that were demonstrated repeatedly to influence mode choice in a review of other mode choice studies. These factors were:

Waiting time between vehicles. Often referred to as headways, this was the interval between vehicles. Levels were chosen to encompass the expected headways of any new or existing service. For the middle income groups, the levels were (in minutes): 0 (for the automobile), 10, 20, 40 (for the bus). Because the key descriptor of mode in this case is waiting time, the first factor was constructed as a composite factor consisting of both mode and waiting time.

Weekly out-of-pocket cost -- This cost was calculated on the basis of 5 round-trips to the central business district each week. For auto trips, cost was computed for the average city street mileage for trip lengths from the center of the residential zone to the center of the central business district. This resulted in an average estimated usage of 4 gallons each week. For bus fare, weekly cost was computed by multiplying the one-way fare by 10.

In-vehicle travel time -- This is the time spent driving a car or riding a bus to or from work. It is the time from entering the vehicle to disembarkation. The shortest time was calculated as driving time by car (22 minutes), and the longest time was the scheduled trip time from the zone center to the central business district (37 minutes).

The specific levels of each of the factors are listed in Table 8.1. Intermediate levels were chosen to coincide with anticipated systems changes and to provide a distribution of results that most evenly represented the entire range of possible values for the levels of each factor.

8.4.2. Latin square design of factors and levels. The survey instrument elicited preference rankings for a Latin Square design made up of these factors and levels. Four separate Latin Square Designs were developed and the modes that they represent were presented randomly to subjects. An example of the factors and levels in the first Latin Square are also presented in Table 8.1 and corresponding survey segment is presented in Appendix B. Each subject was given specific

Figure 8.3

CHARLOTTE, N.C. (CENTRAL AND EASTERN SECTIONS):
LOCATIONS OF RESPONDENTS AND WORK PLACE

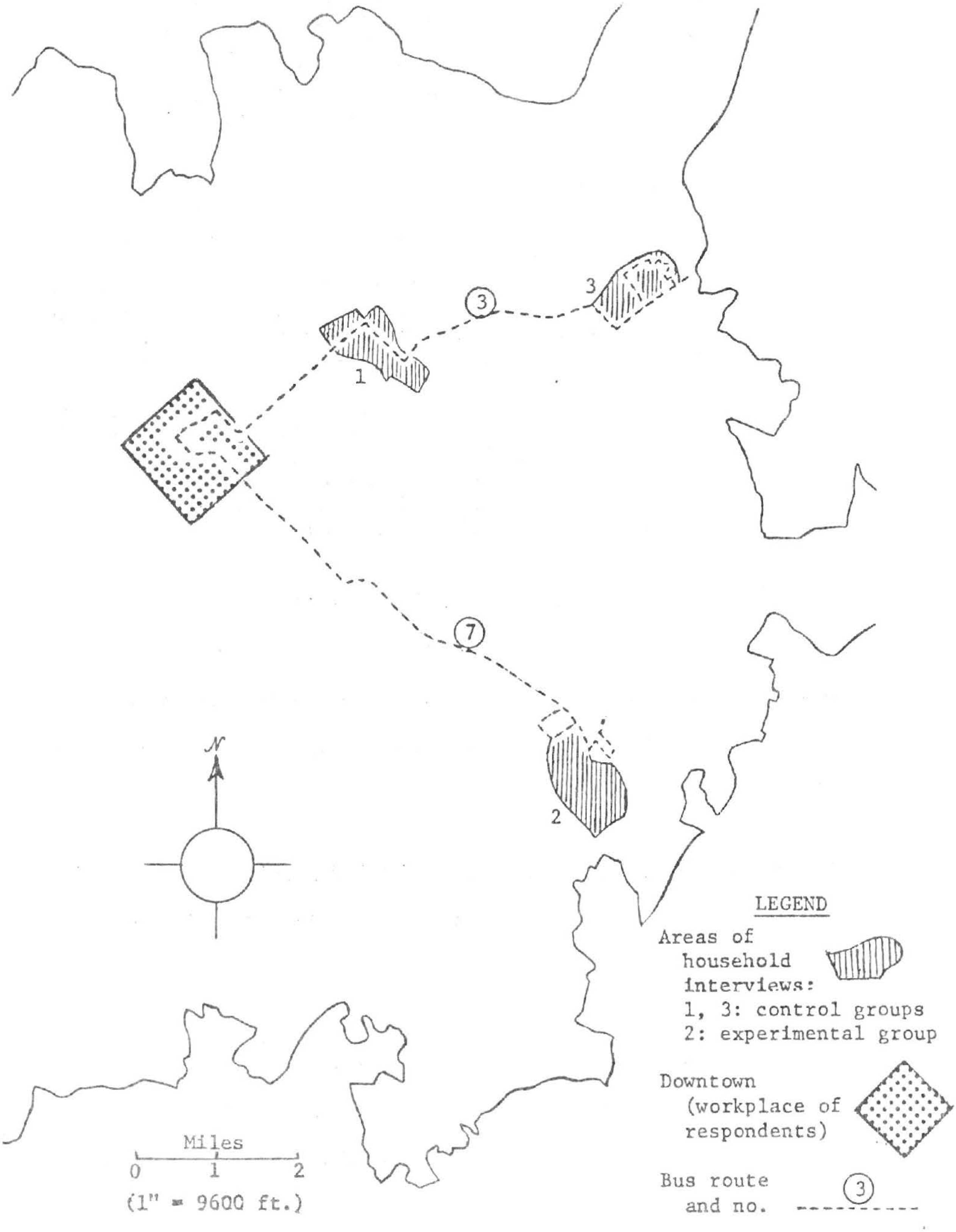


Table 8.1

Latin Square Design for Charlotte Study

	Factor I Mode and Waiting Time				Factor II Cost				Factor III Travel Time			
	Car	Bus										
Item Number	0	10	20 (minutes)	40	4	5	8	10	22	25	30	37
1	X				X				X			
2	X					X				X		
3	X						X				X	
4	X			X								X
5		X			X					X		
6		X				X					X	
7		X					X					X
8		X					X	X				
9			X		X						X	
10			X			X						X
11			X				X		X			
12			X					X		X		
13				X	X							X
14				X		X			X			
15				X			X			X		
16				X				X			X	

Table 8.2

Average Part-Utility for Conjoint Measurement in Experimental Zone

Factor and level	Average Part-Utility*
A. Mode and Waiting Time (minutes)	
1. Car, 0	-1.01
2. Bus, 10	-0.27
3. Bus, 20	0.20
4. Bus, 40	1.08
B. Cost	
1. $4.00	-0.94
2. $5.00	-0.56
3. $8.00	0.38
4. $10.00	1.13
C. Travel Time (minutes)	
1. 22	-0.19
2. 25	-0.06
3. 30	0.02
4. 37	0.23

*More negative value indicates higher preference.

instructions in how to deal with this cumbersome task in a systematic and structured approach. The instructions are also shown in Appendix B.

8.4.3. <u>The MONANOVA algorithm</u>. The MONANOVA algorithm was used to analyze the responses. This program, developed by Kruskal (1969) provides estimates for the partutility of each level of each factor. The average of these estimates for the experimental group are listed in Table 8.2.

Table 8.2 illustrates that part-utilities can have negative or positive values. For this algorithm, a more negative value indicates higher preference. The importance of these values is the relative magnitude of the difference between values associated with specific factor levels. This is illustrated by the following question: Is the difference in values associated with a change in weekly cost from $4 to $8 more than equalled by a change from bus (10 minutes wait) to car. From Table 8.2, on the average, the differences in part-utility values associated with these changes are 1.32 and 74 respectively; on the average, the change in cost would more than compensate for the loss of utility from a change in mode.

Intermediate values between levels can be interpolated and a wide range of scenarios about future conditions can be simulated by calculating overall utility and comparing results for proposed modes in each scenario. Other, more sophisticated simulation techniques can also be employed that take into account intervening variable. Benjamin and Sen (1980) discuss some of these techniques; there is also a brief discussion of these techniques in Chapter 10 of this manual.

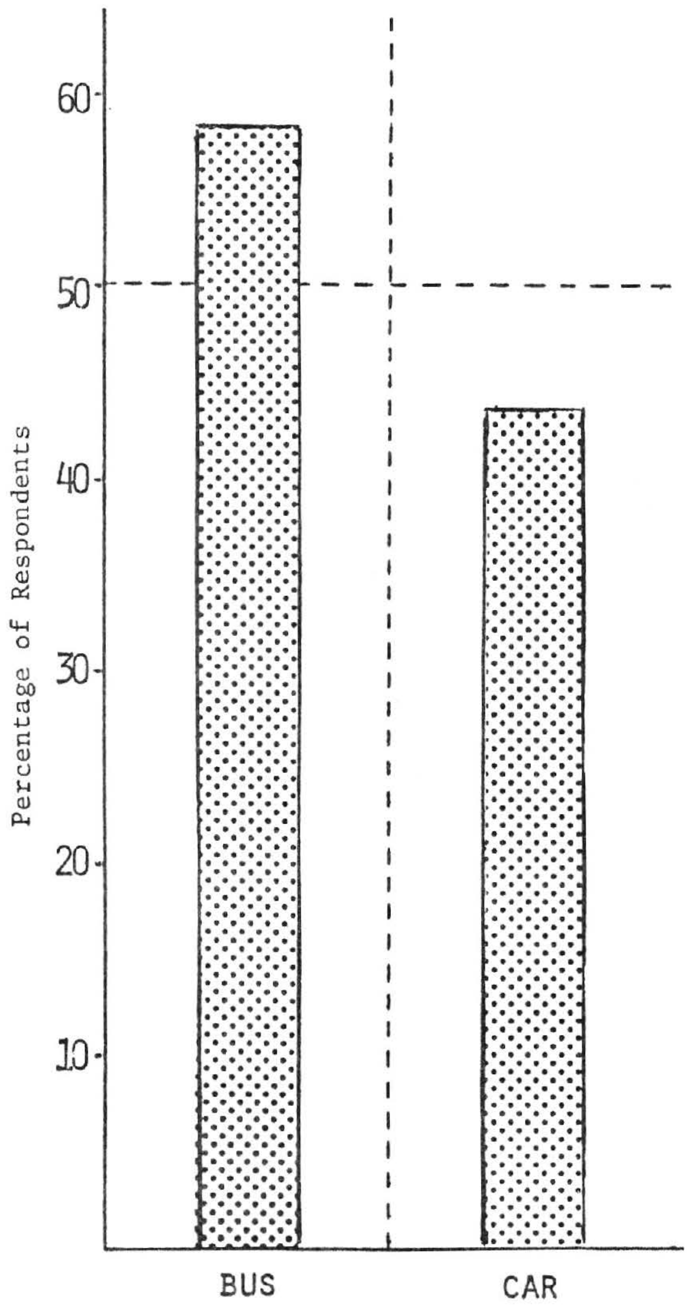
8.4.4. <u>Simulation of future conditions</u>. A simulation of future conditions demonstrates the utility of the conjoint measurement approach. There was a special interest in forecasting demand for public transit under conditions that could result from a change in availability of gasoline. In this scenario, it is assumed that an express bus is introduced at low cost and that the bus takes about the same time to get to the central business district as does the car. The scenario is summarized as:

Mode	Waiting Time	Weekly Cost	Travel Time
Car	0	$8 ($2/gal.)	30
Bus	10	4 ($.40/trip)	30

The simulation model was a simple utility choice model. Overall utility for each mode in the scenario was calculated for each subject by summing the part-utilities of the corresponding mode. The simulated choice for each subjected was decided by comparing overall utilities for each mode; the highest utility was the subject's choice. These choices were tabulated for all subjects in the experimental zone. The results are illustrated in Figure 8.4. The simulation results in a forecast of just about an even split with slightly more people chosing to take the bus. This indicates a high potential demand under these extreme conditions. However, even at $2.00/gal. and with a very high travel time, respondents consider bus unfavorably. On the other hand, the results indicate that an increase in gasoline prices would motivate a change in the mode of preference for the majority of residents who live in this neighborhood and who work in the central business district.

Figure 8.4

CONJOINT MEASUREMENT:
SIMULATED RESULTS FOR
GASOLINE-SHORTAGE SCENARIO



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IX -- FUNCTIONAL ANALYSIS: A METRIC ANALYSIS OF MULTIATTRIBUTE DECISIONS.

Functional analysis is a conjoint approach but it differs from other conjoint approaches in that it is based on the assumption that preference ratings are interval scaled (other conjoint approaches are based on the assumption that subjects can provide only rank order data). This enables analysis using conventional statistical techniques. However, subjects must not only indicate which items are most preferred, but by how much; the survey questions must be formulated in a way that properly elicits these interval estimates.[1]

9.1. Responses to functional analysis questions.

Responses to functional survey questions are analyzed by conventional statistical techniques. One advantage of functional measurement is that conventional statistical methods can be used to find the salience of factors and levels of factors that describe transport modes. In fact, if it is assumed that response error is normally distributed, regression analysis and analysis of variance (ANOVA) can be used to test the validity of various preference functions. This makes it easy to test for interactions between levels of different factors.

In Figure 9.1, the part utilities of a linear model with weak interactions are graphically represented for two factors. The two factors are mode and waiting time and cost. Data were from the experimental zone in the Charlotte study which is discussed in more detail in Chapter 8 and the end of this chapter. If the lines are parallel this indicates a linear model because the part-utility of the

[1]The validity of this assumption can be tested empirically.

factor level represented inside the graph (in this case cost) contributes equally to the levels of the other factor (in this case mode and waiting time). In other words, for a linear model, the difference in preference for cost is the same, no matter what the mode is. When the lines are not parallel, this indicates an interaction. This is also illustrated in Figure 9.1. Cost has a small effect on the relative preferences for mode. For high cost factor II, level 4. On the average, bus and car are equally preferred, but at low cost, (factor II, level 1) bus is preferred substantially less than car. Since the lines are never quite parallel, slight differences are attributed to a random error term. Under normal assumptions, the significance of this interaction can be tested by using ANOVA which is available in statistical packages such as SPSS. In this case, all analysis is done from responses from the same subject.[1]

9.2. Data requirements for functional analysis.

Data requirements for functional analysis are similar to data requirements of conjoint measurement. As in conjoint measurement, the survey consists of ratings of stimuli that are formed by combining levels of key factors. As mentioned in the prior chapter, if all combinations of factors and levels are used in presenting these stimuli, the survey task becomes cumbersome. This is referred to as a full-factorial design. By carefully selecting only some factor-level combinations, the size of the survey task can be reduced dramatically.

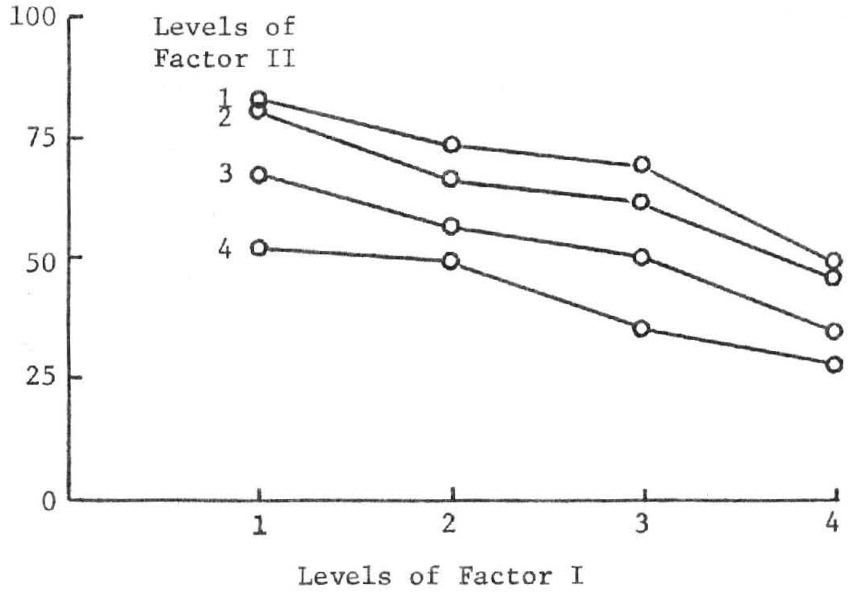
---

[1] If a linear model or other pre-specified model fits well, it is also taken as evidence that assumptions of interval responses are valid.

Figure 9.1

AVERAGE RATINGS FOR
FACTOR I AND II INTERACTIONS

GROUP 2



Factor I: Mode and waiting time

Factor II: Cost

Partial factorial designs, such as Latin square designs which provide balanced information, are most useful in this case.

In a linear model, part utilities are estimated from the mean of the ratings of all items that are described by the same factor level; for example, all modes that are described as having 20 minutes travel time. If a linear model were assumed, the analysis would be straight forward, even when most partial factorial designs are used.

In a polynomial model (one that allows interactions), part utilities are calculated from the means of item ratings characterized by a set of factor levels, e.g. all modes which cost 50 cents per trip and take 10 minutes. Sufficient information on any interactions of interest must be included in the raw data. In other words, for a partial design, the survey design must be balanced with respect to the interactions of interest.

When using a partial factorial design, there is usually insufficient information to test for various interactions. However, by carefully planning the survey instruments so that responses to questions from complimentary partial factorial designs are obtained from different samples, it is possible to test for interactions at the aggregate level. For example, by distributing the complete set of Latin squares to different subsamples, the complete factorial design is represented when all observations are considered together, and hence all interactions can be tested.

There is a second advantage to testing at the aggregate level. By doing this, only one preference function is assumed for the entire sample. This enables easier comparison between subjects. If preference functions are tested for individual subjects, it is likely that different polynomial functions will be found that are best for each subject. Comparison of part-utilities estimated from different functions is like comparing apples and oranges; it can't be done.

Data requirements are similar to those of conjoint measurement except that the directions must elicit ratings. Usually a scale from 0 - 100 can be used. Other scales have also been found useful, including intended usage or likelihood of mode split. Also, researchers have found that tie scores can be permitted and that it is useful to "anchor" extreme values by assigning them an initial score.

Intended usage and likelihood of mode choice are variables that measure subjective assessments of future overt actions. It has been found to be useful to analyze these modal comparisons using a modified regression analysis. In this case, likelihood of mode choice is the dependent variable and the modal descriptors are the independent variable. In this case, assumption of a logistic model has been found useful. This approach is discussed in detail by Louviere, et al (1981).

To use functional analysis, data requirements include:

Question format -- a series of items, carefully and systematically described by a set of comparable factors. The items are either listed one at a time or in pairs according to transportation mode.

If the items are listed one at a time, a space is provided next to each for the preference rating. A modified version of this provides for a rating scale based on an overt action such as intended mode usage. In this case the rating scale consists of equally spaced numbers from "1", no intended usage, to "9" or "11", intended use for all trips. Extremities and intermediate points need to be labelled.

If items are listed in modal pairs, a space is provided for an indication of the likelihood that each mode will be chosen based on modal descriptors. A definition of the likelihood, or percentage of times that each mode is used, is provided in the instructions.

Possible scales -- preference, overall rating, or overt actions such as intended usage, likelihood of mode choice or percentage of times each mode a chosen.

Transportation applications -- analysis of mode choice, market shares, or other choice processes, market segmentation or analysis of transportation policy options.

To use this technique a format is required that is similar to the following illustrative example:

This is the same example as that used in the preceding chapter. Bus services are suggested with levels of bus fare and travel time as follows:

bus fare - free, $ .50, $1.00

travel time (minutes) - 10, 15, 20

Instructions - Consider the options for bus service that are listed below. Each service is described by a bus fare and a travel time. The bus fare is for a one-way trip. The travel time is the time it takes from the moment you enter the bus until you depart.

We would like to know your opinion about which service you would most prefer for your daily trip to work. Indicate this by selecting the best service for you and placing a number next to it between 0 and 100. A rating of 0 indicates least preference and a rating of 100 indicates most preference.

Next, select the service that is second best for you and place a rating next to it. This rating should be less than or equal to the rating of the best service. Continue until all services have been rated.

Bus fare (dollars)	Travel time (minutes)	Rating
free	10	______
1.00	20	______
.50	20	______

9.3. An example of a study of consumers preference

An example of the use of functional analysis is also the study of consumer perceptions in Charlotte, NC. The study of consumer perceptions, reported in Chapter VIII of this manual, also included a set of questions which were most appropriately analyzed using functional analysis. The background and purpose of the study are described there. The function analysis questions were for the same levels of the same factors and made use of the same Latin Squares as the conjoint measurement study. The questions varied in order to presentation and evaluation criteria; subjects were asked to rate each question on a scale from 0 (least preferred) to 100 (most preferred).

9.3.1. Analysis of responses. Responses were analyzed by finding the average response for each each factor level. The part-utility estimates are presented in Table 9.1. The values are interpreted in a way that is similar to the interpretation of part-utilities that result from conjoint measurement. It is the 2 relative size of the interval between factor levels that is most important. Overall, the range of mode and waiting time is largest, indicating the most importance in decision- making while the range of travel time is smallest, indicating smallest influence.

9.3.2. Forecasting of future mode choices. Future choices were forcasted by using a simple preference model. As in the conjoint measurement approach, overall utility was calculated as the sum of the part-utilities for any mode that is considered; modes under consideration are described by forecasting future market conditions and proposed systems changes.

Table 9.1
Average Part-Utility for Experimental Group Using Functional Analysis

Factor and level	Average Part-Utility*
A. Mode and Waiting Time (minutes)	
1. Car, 0	70.4
2. Bus, 10	61.2
3. Bus, 70	53.6
4. Bus, 40	39.7
B. Cost	
1. $4.00	68.2
2. $5.00	63.4
3. $8.00	52.2
4. $10.00	41.2
C. Travel Time (minutes)	
1. 22	58.3
2. 25	57.8
3. 30	56.1
4. 37	52.8

*Higher value indicates higher preference.

Response was forecast for the same scenario as the conjoint measurement analysis; in this scenario a high level of bus service is provided after gasoline prices have risen to $2 per gallon. For easy reference, the modes under consideration in this scenario are listed below:

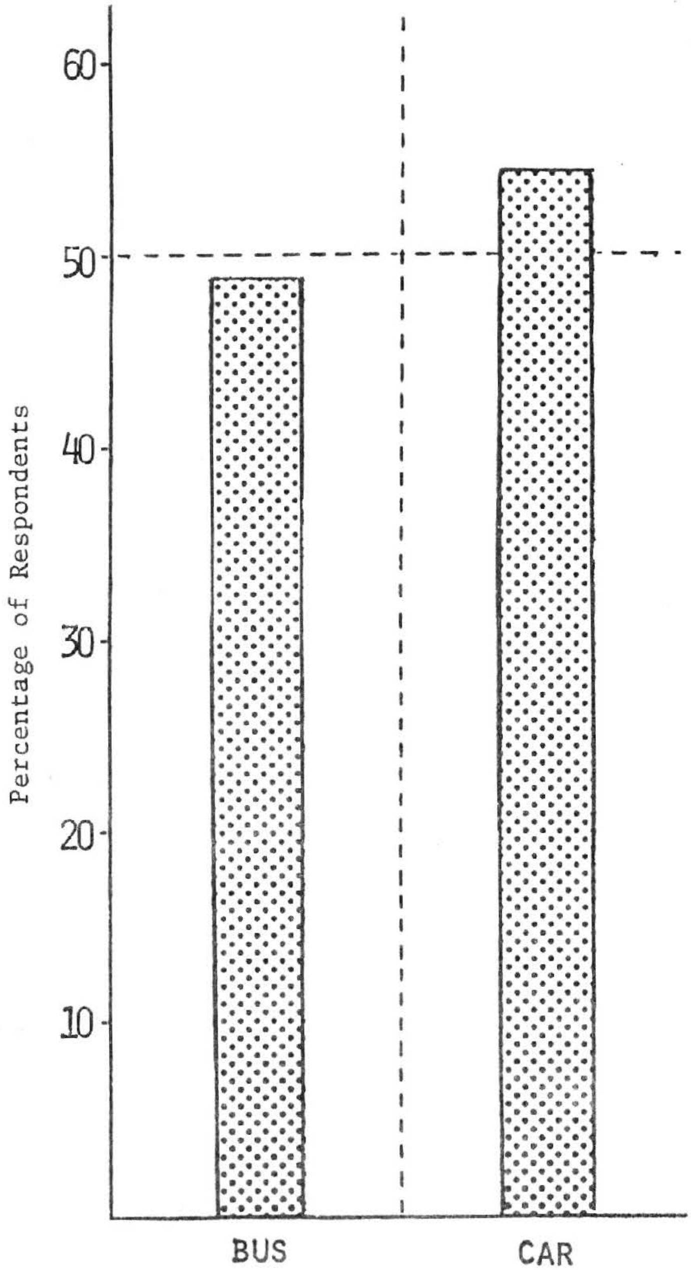
Mode	Waiting Time	Weekly Cost	Travel Time
Car	0	$8.00($2/gal)	30
Bus	10	$ .40(per trip)	30

The results of the analysis, in the experimental zone, are illustrated in Figure 9.2. The simulation forecasts an almost even mode split between car and bus, but this time car is slightly favored. The results are interpreted in the same way as the results from conjoint measurement. The technique forecasts a substantial shift to transit as the mode of preference. However, despite this shift, a car remains the mode of the highest preference for most of these residents. In other words, a virtual doubling of gasoline prices and the introduction of low cost, high service level transit is not enough of a change to induce a change in preference for these residents. Contingency plans, in case of gasoline shortages, should take this into consideration.

It should also be noted that although results are similar for conjoint measurement (as reported in Chapter 8) and functional analysis, the differences are significant. Careful validation of assumptions is necessary here. One way to validate simulations is

Figure 9.2

FUNCTIONAL ANALYSIS:
SIMULATED RESPONSE TO
HIGH GASOLINE PRICES FOR
EXPERIMENTAL GROUP



reproduce existing conditions for a pilot study and compare results of simulated and observed choices.

The results of these techniques can help form the basis of a detailed planning strategy.

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X -- COMPARISONS AND CONCLUDING REMARKS

By now the reader who is new to attitudinal measurement must have some questions about what techniques to choose and when to choose them. Here are some guidelines.

1. Decide whether you need general information about user goals and opinions or specific information for an alternatives analysis.

    * Techniques that are best for general information are:
      --Unidimensional scales
      --Multidimensional scales

    * Techniques that are best for alternatives analysis are:
      Conjoint Measurement
      --Functional Analysis

2. In conjunction with the amount of information needed, there is consideration of cost. Cost is directly related to the survey format. Personal interviews are by far the most costly. Cost is also related to sample size.

    * The technique that can be completed by telephone is:
      --Unidimensional scaling

    * Techniques that can be completed by mail are:
      --Unidimensional scaling
      --Some forms of multidimensional scaling

    * Techniques that usually require a personal interview format are:
      --Conjoint measurement
      --Functional analysis

3. Consider the degree of difficulty in analyzing results.

    * The technique that requires only a knowledge of elementary statistics is:
      --Unidimensional scaling

    * Techniques requiring advanced statistics are:
      --Principal components analysis
      --Functional analysis

Table 10.1

Tabular Guide to Use of Techniques

	(1)	(2)	(3)	(4)	(5)	(6)
I. Uses						
1. Provides high degree of detailed information				X	X	X
2. Provides general information about individual transport attributes	X					
3. Provides overview of many general transport attributes		X	X			
4. Can be used to group market segments		X	X	X	X	X
5. Easily used to detect interactions						X
II. Costs						
6. Easily self-administered	X	X	(X)			
7. Requires personal interview format (usually)			(X)	X	X	X
8. Easily adopted to telephone	X	X				

1. Unidimensional scales
2. Factor analysis
3. Multidimensional scaling
4. Trade-off analysis
5. Conjoint measurement
6. Functional Analysis

Tabular Guide to Use of Techniques (cont)

III. Computer Analysis	(1)	(2)	(3)	(4)	(5)	(6)
9. Easily analyzed on popular packages (SPSS)	X	X				
10. Can be analyzed on popular packages after proper preparation						X
11. Requires special computer packages				X	X	
12. Requires little computer time	X					
13. Requires greater computer time		X	X	X	X	X
14. Requires little statistical background	X					
15. Requires some statistical background		X				
16. Requires special knowledge of programs and procedures			X	X	X	X

behaviors such as mode choice (Golob and Recker (1977) or to analyze travel behavior and attitude relationships by using multiple equation econometric techniques (Charles Rivers Associates, 1978.)

Another approach for marketing applications is to find subjects who have similar viewponts. Subjects who are similar can be clustered together by using cluster analysis on attitudinal measure. Resulting market segments can then be supplied with services that are tailored to their needs.

The future holds promise of more accurate, more easily applied techniques. Linear programming, ideal point conjoint analysis and improved sampling will make these techniques even more cost effective. They can be tailored to virtually any planning or policy problem and in the future it can be expected that a wide variety of new applications will be found. With the continual rise of new challenges in energy conservation, equitable distribution of resources after federal cutbacks, mobility of the disadvantaged citizens, the environment and the quality of life, the potential for contributions of these techniques is virtually limitless.

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APPENDIX

A SURVEY OF THE LITERATURE ON PASSENGER TRANSPORTATION ATTRIBUTES INFLUENCING MODAL CHOICE

by

Richard S. Watt

with the assistance of

Avis Thompson

A SURVEY OF THE LITERATURE ON PASSENGER TRANSPORTATION ATTRIBUTES INFLUENCING MODAL CHOICE

The use of market segmentation techniques for transportation and transit planning is based on the determination of attitudes and preferences of individuals with respect to various aspects or attributes of transportation modes or options. The literature review which follows is designed to survey the literature concerning the attributes of passenger transportation and transit which motivate for or against the choice of specific transportation modes. Seventy-three references, dating from 1968 to 1979, are cited.

The results of the survey are presented in two tabulations. Table 1 tabulates the references (alphabetically by author) against the transportation modes treated in each. Table 2 tabulates the same list of references against a classified list of transportation attributes or characteristics.

TABLE 1: TRANSPORTATION MODES

As will be seen from Table 1, the literature is concerned predominantly with the private automobile and local surface transit (bus), the most common public transit alternative. Fifty-six references treated the private automobile mode; 60 treated local bus transit, and 51 of these treated the two together. Following these modes, in order of frequency of treatment, were carpools (21 citations), local rail (e.g., intraurban subway) transit (16 citations), and demand-responsive modes other than taxis (13 citations). Totals at the end of the last page of Table 1 indicate the frequency of treatment of each mode.

Table 1

TRANSPORTATION MODES

	Private automobile	Carpool (1)	Taxicab	Dial-a-Ride (2)	Surface transit, local (3)	Personal Rapid Transit (4)	Rail transit, local (5)	Rail, interurban (6)	Air	Walking	Bicycle, Motorcycle	Other
Abt Associates (1968)	X				X		X			X		
Abt Associates (1974)					X		X					
Alpert, Davies (1975)	X	X			X					X	X	
Arrillaga (1974)	X			X	X							
Blankenship (1975)	X				X							
Bock (1968)	X	X			X		X	X		X	X	
Brogan, Heathington (1973)	X				X							
Carnegie-Mellon (1968)	X				X							
Constantino, et al. (1974)						X						
Dobson (n.d.)	X	X			X							
Dobson (1974)	X			X	X							
Dobson, Dunbar, et al. (1978)	X	X			X							
Dobson, Golob, et al. (1974)				X								
Dobson, Nicolaidis (1974)						X						
Dobson, Tischer (1976)	X	X			X							
Dobson, Tischer (1977)	X	X			X							
Dupree, Pratt (1973)	X	X			X							
Gensch, Golob (1974)						X						

[1]Includes vanpools and buspools.

[2]Includes shared-ride taxis, demand-responsive jitneys, vans and buses.

[3]Fixed-route-and-schedule bus and streetcar.

[4]Includes "people movers," automated guideway and dual-mode systems.

[5]Typically, intraurban subway.

[6]Includes commuter and intercity rail service.

Table 1 (Continued)

	Private automobile	Carpool (1)	Taxicab	Dial-a-Ride (2)	Surface transit, local (3)	Personal Rapid Transit (4)	Rail transit, local (5)	Rail, interurban (6)	Air	Walking	Bicycle, Motorcycle	Other
Gensch, Golob (1975)						X						
Gilbert, Foerster (1977)	X				X							
Golob (1970)	X	X			X		X	X		X		(7)
Golob, Canty, et al. (1970)				X								
Golob, Horowitz, Wachs (1977)	X				X							
Golob, Nicolaidis (1976)	X				X							
Golob, Recker (1977)	X				X							
Gustafson, et al. (1971a)				X								
Gustafson, et al. (1971b)	X			X	X							
Hartgen (1973)	X				X							
Hartgen, Tanner (1971)	X				X							
Haynes, Fox, et al. (1977)	X	X		X	X	X	X					(8)
Hoey, Levinson (1977)	X				X							
Horowitz (A. D.) (1978)	X	X										
Horowitz (A. D.), Sheth (1977)	X	X										
Horowitz (A. J.) (1977)	X				X					X		
Horton, Louviere (1974)					X							
Jacobson, et al. (1977)					X			X	X			
Keck, Liou (1974)	X				X							
Kemp (1973)	X				X							
Krishnan, Golob (1977)	X				X		X					
Levin, Gray (1979)	X	X										

[1 - 6] See first page of table.

[7] "Other" unspecified.

[8] "Other tracked" (monorail and channel) vehicles.

Table 1 (Continued)

	Private automobile	Carpool (1)	Taxicab	Dial-a-Ride (2)	Surface transit, local (3)	Personal Rapid Transit (4)	Rail transit, local (5)	Rail, interurban (6)	Air	Walking	Bicycle, Motorcycle	Other
Levin, Herring (1979)	X								X			
Lovelock (1973)	X				X		X					
McCarthy (1977)	X						X	X				(9)
McMillan, Assael (1969)	X				X		X	X	X			(9)
Meyburg, et al. (1974)	X				X							
Myers (1970)	X		X	X	X							
Navin, Gustafson (1973)				X	X							
Nicolaidis, et al. (1977)	X				X							
Olsen, Smith (1974)					X							
Peat, Marwick, et al. (1976)	X	X			X							
Pratt, et al. (1977)	X	X			X							
Pulliam, et al. (1976)	X				X		X					
Pun, Kidder (1976)	X	X			X					X	X	
Recker, Golob (1976)	X				X							
Recker, Stevens (1976)	X		X		X					X		
Reish, Surti (1972?)	X				X							
Scardino, Kerpelman (1977)	X	X			X						X	(10)
Schimpeler Corradino (1974)				X	X							
Sen, Benjamin (1979)	X	X	X		X					X	X	
Smith (1970)					X		X					
Talvitie (1973)	X				X		X					
Talvitie, Kirshner (1978)	X	X			X		X					
Tehan, Wachs (1972)	X				X	X						

1 - 6 See first page of table.

9 Intercity bus.

10 Hitchhiking.

Table 1 (Continued)

	Private automobile	Carpool (1)	Taxicab	Dial-a-Ride (2)	Surface transit, local (3)	Personal Rapid Transit (4)	Rail transit, local (5)	Rail, interurban (6)	Air	Walking	Bicycle, Motorcycle	Other
Train (1978)	X	X			X							
Transportation-Employment Project (1971)	X				X							
USDOT, UMTA (1973)			X	X	X		X					
Vitt, et al. (1969)				X								
Voorhees (1974)	X	X	X		X							
Wachs (1976)	X				X		X					
Wegmann, et al. (1979)	X	X	X	X	X							
Wigner (1973)	X				X		X	X				
Worcester (1969)	X				X							
Yancy (1972)					X							
Total citations[11] (73 references)	56	21	6	13	60	6	16	6	3	8	5	5

1 - 6 See first page of table.

11 Private automobile and local surface transit treated together by 51 references.

TABLE 2: TRANSPORTATION ATTRIBUTES

It was characteristic of the literature that the same, or similar, attributes of passenger transportation were found under many different terms. For purposes of tabulation, an attempt has been made to find a single term for each distinct attribute.

No attempt has been made in this tabulation to distinguish attributes as "positive" or "negative." Bock (1968) presents a detailed and comprehensive list of transportation attributes, annotated according to their incentive or disincentive effect on the choice of various modes. Obviously, in some cases, the same attribute may be "positive" or "negative," depending on the need or preference of the individual, and the modal options in question. In other cases, a quantitative aspect of an attribute (e.g., amount of fare, length of waiting time) may determine its incentive or disincentive effect. We have not attempted to screen these quantitative aspects.

Relative Importance of Transportation Attributes

Preceding Table 2 is an outline of the attributes tabulated, together with the frequency with which each attribute appears in the literature surveyed. This frequency may be taken as an index of the relative importance of each attribute to transportation planners, and, presumably, to the public. On this basis, it appears that the most important attribute is time (cited by 64 of the 73 references), specifically time spent in actual travel (56 citations). Second in importance is monetary cost (56 citations), especially transit fares (33 citations).

Following time and cost importance are schedules (49 citations), with emphasis on dependability (43 citations); and on-vehicle comfort (47 citations), with emphasis on privacy and crowding (32 and 27 citations respectively), temperature, ventilation and lighting in the vehicle (30 citations), and seating (27 citations), usually availability of seating (26 citations).

Also of importance (cited by over half the references) are convenience (42 citations); out-of-vehicle comfort (40 citations), principally shelter from weather at transit stops and stations (35 citations); routing (39 citations); safety and security (39 citations), including both safety from accidents and protection from assault and other crime; and psychological and aesthetic aspects of travel (37 citations), with emphasis on the feeling of enjoyment or pleasure associated with use of a given mode (22 citations) and the appearance and modernity of the vehicle or system (24 citations).

Special Lists of Transportation Attributes

A few of the references surveyed included highly detailed lists of transportation attributes, which we found impractical to incorporate in our tabulation. The comprehensive list of transportation incentives and disincentives compiled by Bock (1968) has already been mentioned. Golob, Canty et al. (1970, fig. 3, p. 9) also present a detailed list of transportation system characteristics.

Wegmann et al. (1979) present detailed tabulations of specific factors relating to transit vehicle appearance, interiors, seating comfort, and transit system amenities. Krishman and Golob (1977) detail the attributes of private automobiles and automobile transportation.

Olsen and Smith (1974) offer a list of characteristics of bus transit, under the general headings of 1) Injury risk, 2) Health risk, 3) Annoyance, 4) Short-duration time pressure, and 5) Long-duration time pressure.

One group of references (Dobson, 1974; Dobson, Golob et al., 1974; Golob, Canty et al., 1970; Gustafson et al., 1971a, 1971b; Vitt et al., 1969) reproduce an identical list of thirty-two transportation attributes. Most of these are tabulated in Table 2. The remainder, unique to this list, are:

--More phones available in public places used to call for service

--More chance of being able to arrange ahead of time to meet and sit with someone you know

--A vehicle whose size and appearance do not detract from the character of the neighborhood through which it passes

--Calling for service without being delayed

--More chance of riding with different kinds of people

--Availability of coffee, newspapers and magazines in the vehicle

A number of transportation characteristics, mentioned by only one or two references, were not included in Table 2. These were:

Attribute	Reference
Ease of travel with children	Alpert, Davies (1975)
Sense of well-being	Arrilaga (1974)
Ease of finding where to go	Dobson (n.d.)
Automatic control of vehicle	Constantino et al. (1974); Gensch, Golob (1974, 1975)
Ability to take along family, friends	Hartgen (1973); Hartgen, Tanner (1971)
Sharing of driving	Levin, Gray (1979)
Mobility	Meyburg et al. (1974)
Ease of making trip (no advance planning necessary)	" " "

Attribute	Reference
Driver capability	Recker, Stevens (1976)
Indirect monetary costs	Scardino, Kerpelman (1977)
Visibility outside of vehicle	USDOT/UMTA (1973)
Vehicle priority traffic control	Voorhees (1974)
User confidence in obtaining service	Wegmann et al. (1979)

Format of Table 2

Table 2 tabulates the references (alphabetically by author) against a classified list of transportation attributes. The size of the table necessitates its division into three main sections. Part A tabulates the whole list of attributes against about one-third of the references (Abt Associates to Colob). Part B does the same for references from Gustafson to Peat, Marwick, and Part C for references Pratt to Yancy.

Preceding the table is an outline of the list of transportation attributes presented in the table, with an indication of the frequency (number of citations and percentage, out of a total of 73 references) with which each attribute is treated in the literature surveyed.

OUTLINE OF TABLE 2
(Transportation Attributes)

	Frequency of Citation (Total of 73 Refs.) Number	Percent
AVAILABILITY OF MODE (Includes: a. availability of service in a given locality b. availability of mode to individual, conditioned by ability to use)	14	19
RELIABILITY OF MODE (Includes: a. likelihood of breakdown or down-time for repairs b. ability of mode to operate under adverse conditions, e.g. severe weather)	7	9.5
AVAILABILITY OF INFORMATION (Includes: a. printed schedules, route maps, etc. b. posted information, signs at stops, on vehicles, etc. c. availability of information via telephone or in person from drivers or other system employees)	18	25
COSTS	56	77
General/Unspecified	30	41
Fares	33	45
Automobile ownership and operating	16	22
Parking, tolls	13	18
Other	6	8
TIME	64	88
Traveling	55	75
Waiting	42	57.5
Walking	37	51
SCHEDULES	49	67
Frequency/Headways	11	15
Dependability	43	59
Hours of Service	12	16
Choice of Pickup Time	17	23
Flexibility	3	4
ROUTING	40	55
Areal Coverage	17	23
Proximity to Home	15	20.5
Proximity to Destination	19	26
Directness	20	27
Flexibility	14	19

	Number	Percent
CONVENIENCE	42	57.5
General/Unspecified	24	33
Simplicity of Use	7	9.5
Transfers	21	29
(Includes: a. transfers on a single mode or system; b. necessity of changing from one mode or system to another)		
Parking	7	9.5
Traffic Congestion	18	25
Ease of Travel from Vehicle to Destination	4	5
COMFORT, AMENITIES ON VEHICLE	47	64
General/Unspecified	25	34
Ease of Vehicle Entry, Exit	6	8
Seating	27	37
Availability	26	36
Comfort	18	25
Provision for Standees	3	4
Smoothness of Ride	18	25
Noise	22	30
Cleanliness of Vehicle	15	20.5
Temperature, Ventilation, Lighting	30	41
Crowding	27	37
Privacy	32	44
Acceptability of Fellow-Passengers	15	20.5
Ease of Meeting, Talking with Friends	21	29
Opportunity to Relax, Read	16	22
Availability of Radio	8	11
Space for Parcels	21	29
Space for Wheelchairs, Baby Carriages, etc.	9	12
Courtesy/Attitude of Driver/Operator	7	9.5
COMFORT, AMENITIES--OUT OF VEHICLE	40	55
Shelter from Weather	35	48
Pedestrian Traffic, Crowding	4	5
Convenience of Fare Payment	13	18
Amenities at Stops, Stations	10	14
SAFETY, SECURITY	39	53
General/Unspecified	3	4
Protection from Crime	24	33
Safety from Accidents	33	45
PSYCHOLOGICAL, AESTHETIC	37	51
Enjoyment/Pleasure in Using Mode	22	30
Sense of Autonomy, Independence	6	8
Appearance/Modernity of Vehicle/System	24	33
Social Status	11	15
SOCIAL VALUES	15	20.5
Pollution	12	16
Fuel Conservation	5	7

Table 2

TRANSPORTATION ATTRIBUTES
Part A (Abt - Golob)

				COSTS					TIME		
	Availability of Mode	Reliability of Mode	Availability of Information	General/Unspecified	Fares	Automobile ownership and operating	Parking, tolls	Other	Traveling	Waiting	Walking
Abt Associates (1968)		X								X	
Abt Associates (1974)	X	X	X		X	X				X	X
Alpert, Davies (1975)				X			X	X	X		
Arrillaga (1974)				X					X		
Blankenship (1975)				X		X			X		
Bock (1968)	X			X		X			X	X	
Brogan, Heathington (1973)	X			X	X		X		X		
Carnegie-Mellon (1968)											
Constantino, et al. (1974)					X				X	X	
Dobson (n.d.)				X	X	X	X		X	X	X
Dobson (1974)			X		X				X	X	X
Dobson, Dunbar, et al. (1978)										X	
Dobson, Golob, et al. (1974)			X		X				X	X	X
Dobson, Nicolaidis (1974)					X				X	X	
Dobson, Tischer (1976)				X			X		X	X	X
Dobson, Tischer (1977)				X			X		X	X	X
Dupree, Pratt (1973)	X					X	X		X		
Gensch, Golob (1974)					X				X	X	
Gensch, Golob (1975)					X				X	X	
Gilbert, Foerster (1977)											
Golob (1970)	X		X	X	X				X	X	X
Golob, Canty, et al. (1970)	X		X	X	X				X	X	X
Golob, Horowitz, Wachs (1977)	X								X	X	X
Golob, Nicolaidis (1976)					X	X			X	X	X
Golob, Recker (1977)					X			X	X	X	X

Table 2

Part A (continued)

	SCHEDULES					ROUTING				
	Frequency/Headways	Dependability	Hours of Service	Choice of Pickup Time	Flexibility	Areal Coverage	Proximity to Home	Proximity to Destination	Directness	Flexibility
Abt Associates (1968)		X					X	X		X
Abt Associates (1974)										
Alpert, Davies (1975)		X			X					
Arrillaga (1974)		X								
Blankenship (1975)		X								
Bock (1968)	X	X	X	X	X		X	X		X
Brogan, Heathington (1973)	X		X				X		X	
Carnegie-Mellon (1968)						X				
Constantino, et al. (1974)		X				X		X		
Dobson (n.d.)		X				X	X	X	X	
Dobson (1974)		X	X	X					X	
Dobson, Dunbar, et al. (1978)		X						X		
Dobson, Golob, et al. (1974)		X	X	X					X	
Dobson, Nicolaidis (1974)		X				X				
Dobson, Tischer (1976)		X			X					
Dobson, Tischer (1977)		X		X						
Dupree, Pratt (1973)										
Gensch, Golob (1974)		X								
Gensch, Golob (1975)		X								
Gilbert, Foerster (1977)				X						
Golob (1970)		X	X	X		X	X		X	
Golob, Canty, et al. (1970)		X	X	X		X	X		X	
Golob, Horowitz, Wachs (1977)		X							X	X
Golob, Nicolaidis (1976)		X		X					X	X
Golob, Recker (1977)		X		X				X		X

Table 2

Part A (continued)

	CONVENIENCE						COMFORT, AMENITIES ON VEHICLES					
									Seating			(Continued next page)
	General/Unspecified	Simplicity of Use	Transfers	Parking	Traffic Congestion	Ease of Travel from Vehicle to Destination	General/Unspecified	Ease of Vehicle Entry, Exit	Availability	Comfort	Provision for Standees	Smoothness of Ride
Abt Associates (1968)							X		X		X	
Abt Associates (1974)								X	X	X	X	X
Alpert, Davies (1975)	X			X	X							X
Arrillaga (1974)	X						X					
Blankenship (1975)	X	X			X		X					
Bock (1968)	X		X		X		X		X			X
Brogan, Heathington (1973)	X			X					X			
Carnegie-Mellon (1968)	X		X				X					X
Constantino, et al. (1974)							X					X
Dobson (n.d.)	X			X	X		X		X	X		
Dobson (1974)				X				X	X	X		
Dobson, Dunbar, et al. (1978)	X	X				X						
Dobson, Golob, et al. (1974)									X	X		
Dobson, Nicolaidis (1974)	X											X
Dobson, Tischer (1976)	X	X			X	X	X					
Dobson, Tischer (1977)	X	X			X	X	X					
Dupree, Pratt (1973)					X							
Gensch, Golob (1974)							X					
Gensch, Golob (1975)							X					
Gilbert, Foerster (1977)												
Golob (1970)									X	X		
Golob, Canty, et al. (1970)									X	X		
Golob, Horowitz, Wachs (1977)			X		X				X	X		X
Golob, Nicolaidis (1976)			X		X				X	X		X
Golob, Recker (1977)					X				X	X		X

Table 2

Part A (continued)

	COMFORT, AMENITIES ON VEHICLES (Continued)											
	Noise	Cleanliness of Vehicle	Temperature, Ventilation, Lighting	Crowding	Privacy	Acceptability of Fellow-Passengers	Ease of Meeting, Talking with Friends	Opportunity to Relax, Read	Availability of Radio	Space for Parcels	Space for Wheelchairs, Baby Carriages, etc	Courtesy/Attitude of Driver/Operator
Abt Associates (1968)		X	X	X	X			X		X		
Abt Associates (1974)												
Alpert, Davies (1975)	X		X		X		X	X	X	X		
Arrillaga (1974)												
Blankenship (1975)			X		X	X		X				
Bock (1968)	X	X	X	X	X	X	X	X	X			X
Brogan, Heathington (1973)												
Carnegie-Mellon (1968)	X	X	X		X							
Constantino, et al. (1974)	X	X	X		X						X	
Dobson (n.d.)		X		X	X	X		X				
Dobson (1974)	X		X	X	X	X	X			X	X	
Dobson, Dunbar, et al. (1978)												
Dobson, Golob, et al. (1974)	X		X	X	X	X	X			X	X	
Dobson, Nicolaidis (1974)	X		X		X						X	
Dobson, Tischer (1976)				X				X		X		
Dobson, Tischer (1977)				X				X		X		
Dupree, Pratt (1973)												
Gensch, Colob (1974)	X		X		X						X	
Gensch, Colob (1975)	X		X		X						X	
Gilbert, Foerster (1977)								X				
Golob (1970)	X	X	X	X	X		X		X	X		
Golob, Canty, et al. (1970)	X	X	X	X	X		X		X	X		
Golob, Horowitz, Wachs (1977)	X		X	X	X			X				
Golob, Nicolaidis (1976)	X		X	X	X		X	X				
Golob, Recker (1977)	X		X	X	X		X	X				

Table 2

Part A (continued)

	COMFORT, AMENITIES--OUT OF VEHICLE				SAFETY, SECURITY			PSYCHOLOGICAL, AESTHETIC			SOCIAL VALUES		
	Shelter from Weather	Pedestrian Traffic, Crowding	Convenience of Payment of Fare	Amenities at Stops, Stations	General/Unspecified	Protection from Crime	Safety from Accidents	Enjoyment/Pleasure in Using Mode	Sense of Autonomy, Independence	Appearance/Modernity of Vehicle/System	Social Status	Pollution	Fuel Conservation
Abt Associates (1968)	X	X				X				X			
Abt Associates (1974)	X	X	X	X		X							
Alpert, Davies (1975)	X					X	X	X			X	X	X
Arrillaga (1974)					X			X					
Blankenship (1975)					X			X		X	X	X	
Bock (1968)	X						X	X					
Brogan, Heathington (1973)								X					
Carnegie-Mellon (1968)													
Constantino, et al. (1974)				X		X	X						
Dobson (n.d.)	X		X						X			X	
Dobson (1974)	X		X			X	X	X		X			
Dobson, Dunbar, et al. (1978)													
Dobson, Golob, et al. (1974)	X		X					X		X			
Dobson, Nicolaidis (1974)				X		X	X						
Dobson, Tischer (1976)	X					X	X						
Dobson, Tischer (1977)	X					X	X						
Dupree, Pratt (1973)													
Gensch, Golob (1974)				X			X						
Gensch, Golob (1975)				X			X						
Gilbert, Foerster (1977)								X			X		
Golob (1970)	X		X	X		X	X			X	X		
Golob, Canty, et al. (1970)	X		X	X		X	X			X	X		
Golob, Horowitz, Wachs (1977)	X					X	X			X		X	
Golob, Nicolaidis (1976)	X					X	X			X		X	
Golob, Recker (1977)	X					X	X			X		X	

Table 2

Part B (Gustafson - Peat, Marwick)

				COSTS					TIME		
	Availability of Mode	Reliability of Mode	Availability of Information	General/Unspecified	Fares	Automobile ownership and operating	Parking, tolls	Other	Traveling	Waiting	Walking
Gustafson, et al. (1971a)			X		X				X	X	X
Gustafson, et al. (1971b)			X		X				X	X	X
Hartgen (1973)		X		X	X				X	X	X
Hartgen, Tanner (1971)		X		X					X	X	
Haynes, Fox, et al. (1977)			X						X		
Hoey, Levinson (1977)				X					X	X	X
Horowitz (A. D.) (1978)	X				X	X	X		X	X	X
Horowitz (A. D.), Sheth (1977)				X					X		
Horowitz (A. J.) (1977)									X		
Horton, Louviere (1974)			X		X			X	X	X	
Jacobson, et al. (1977)											
Keck, Liou (1974)					X	X	X		X	X	X
Kemp (1973)				X	X		X		X	X	X
Krishnan, Golob (1977)	X								X		
Levin, Gray (1979)				X							
Levin, Herring (1979)				X							
Lovelock (1973)				X					X		
McCarthy (1977)				X					X		
McMillan, Assael (1969)		X		X					X		
Meyburg, et al. (1974)			X	X	X				X		
Myers (1970)	X			X					X	X	X
Navin, Gustafson (1973)	X			X					X		
Nicolaidis, et al. (1977)				X					X	X	X
Olsen, Smith (1974)										X	X
Peat, Marwick, et al. (1976)	X									X	

Table 2

Part B (continued)

	SCHEDULES					ROUTING				
	Frequency/Headways	Dependability	Hours of Service	Choice of Pickup Time	Flexibility	Areal Coverage	Proximity to Home	Proximity to Destination	Directness	Flexibility
Gustafson, et al. (1971a)		X	X	X					X	
Gustafson, et al. (1971b)		X	X	X					X	
Hartgen (1973)		X							X	
Hartgen, Tanner (1971)		X					X	X	X	
Haynes, Fox, et al. (1977)		X		X			X	X		X
Hoey, Levinson (1977)										
Horowitz (A. D.) (1978)		X						X	X	X
Horowitz (A. D.), Sheth (1977)		X								
Horowitz (A. J.) (1977)										
Horton, Louviere (1974)	X	X	X			X	X	X		
Jacobson, et al. (1977)										
Keck, Liou (1974)										
Kemp (1973)										
Krishnan, Golob (1977)						X				
Levin, Gray (1979)										
Levin, Herring (1979)										
Lovelock (1973)		X								
McCarthy (1977)										
McMillan, Assael (1969)									X	
Meyburg, et al. (1974)	X	X				X				
Myers (1970)										
Navin, Gustafson (1973)		X							X	X
Nicolaidis, et al. (1977)		X		X						
Olsen, Smith (1974)		X								
Peat, Marwick, et al. (1976)		X		X						X

Table 2

Part B (continued)

	CONVENIENCE						COMFORT, AMENITIES ON VEHICLES					(Continued next page)
	General/Unspecified	Simplicity of Use	Transfers	Parking	Traffic Congestion	Ease of Travel from Vehicle to Destination	General/Unspecified	Ease of Vehicle Entry, Exit	Seating: Availability	Seating: Comfort	Provision for Standees	Smoothness of Ride
Gustafson, et al. (1971a)									X	X		
Gustafson, et al. (1971b)									X	X		
Hartgen (1973)	X		X		X							
Hartgen, Tanner (1971)	X		X		X							
Haynes, Fox, et al. (1977)						X	X			X		X
Hoey, Levinson (1977)									X			
Horowitz (A. D.) (1978)	X	X	X		X		X		X	X		X
Horowitz (A. D.), Sheth (1977)	X				X		X					
Horowitz (A. J.) (1977)												
Horton, Louviere (1974)	X						X					
Jacobson, et al. (1977)							X					
Keck, Liou (1974)												
Kemp (1973)												
Krishnan, Golob (1977)												
Levin, Gray (1979)												
Levin, Herring (1979)												
Lovelock (1973)	X	X					X					
McCarthy (1977)												
McMillan, Assael (1969)			X		X		X					
Meyburg, et al. (1974)		X						X				
Myers (1970)												
Navin, Gustafson (1973)	X						X					
Nicolaidis, et al. (1977)			X		X				X	X		X
Olsen, Smith (1974)			X						X			X
Peat, Marwick, et al. (1976)	X				X		X					

Table 2

Part B (continued)

	COMFORT, AMENITIES ON VEHICLES (Continued)											
	Noise	Cleanliness of Vehicle	Temperature, Ventilation, Lighting	Crowding	Privacy	Acceptability of Fellow-Passengers	Ease of Meeting, Talking with Friends	Opportunity to Relax, Read	Availability of Radio	Space for Parcels	Space for Wheelchairs, Baby Carriages, etc	Courtesy/Attitude of Driver/Operator
Gustafson, et al. (1971a)			X	X	X	X	X			X	X	
Gustafson, et al. (1971b)			X	X	X	X	X			X	X	
Hartgen (1973)		X		X		X	X		X	X		
Hartgen, Tanner (1971)		X		X	X	X	X		X	X		
Haynes, Fox, et al. (1977)		X			X							
Hoey, Levinson (1977)												
Horowitz (A. D.) (1978)	X		X	X	X		X	X		X		
Horowitz (A. D.), Sheth (1977)												
Horowitz (A. J.) (1977)												
Horton, Louviere (1974)		X	X	X								X
Jacobson, et al. (1977)												
Keck, Liou (1974)												
Kemp (1973)												
Krishnan, Golob (1977)		X		X				X				X
Levin, Gray (1979)							X					
Levin, Herring (1979)												
Lovelock (1973)												
McCarthy (1977)												
McMillan, Assael (1969)				X			X	X				
Meyburg, et al. (1974)	X				X					X		
Myers (1970)												
Navin, Gustafson (1973)												
Nicolaidis, et al. (1977)	X		X	X	X		X	X				
Olsen, Smith (1974)		X	X	X								
Peat, Marwick, et al. (1976)			X		X	X	X		X			

Table 2

Part B (continued)

	COMFORT, AMENITIES-- OUT OF VEHICLE				SAFETY, SECURITY			PSYCHOLOGICAL, AESTHETIC			SOCIAL VALUES		
	Shelter from Weather	Pedestrian Traffic, Crowding	Convenience of Payment of Fare	Amenities at Stops, Stations	General/Unspecified	Protection from Crime	Safety from Accidents	Enjoyment/Pleasure in Using Mode	Sense of Autonomy, Independence	Appearance/Modernity of Vehicle/System	Social Status	Pollution	Fuel Conservation
Gustafson, et al. (1971a)	X		X					X		X			
Gustafson, et al. (1971b)	X		X					X		X			
Hartgen (1973)	X		X			X	X	X	X	X			
Hartgen, Tanner (1971)	X		X			X	X	X	X	X			
Haynes, Fox, et al. (1977)	X			X		X	X			X			
Hoey, Levinson (1977)	X												
Horowitz (A. D.) (1978)	X					X	X	X		X	X	X	X
Horowitz (A. D.), Sheth (1977)								X			X		X
Horowitz (A. J.) (1977)													
Horton, Louviere (1974)							X			X			
Jacobson, et al. (1977)													
Keck, Liou (1974)													
Kemp (1973)													
Krishnan, Golob (1977)		X				X	X						
Levin, Gray (1979)													X
Levin, Herring (1979)					X			X					
Lovelock (1973)							X	X		X	X		
McCarthy (1977)													
McMillan, Assael (1969)	X						X	X	X	X			
Meyburg, et al. (1974)	X			X						X			
Myers (1970)													
Navin, Gustafson (1973)	X						X						
Nicolaidis, et al. (1977)	X						X	X		X		X	
Olsen, Smith (1974)	X												
Peat, Marwick, et al. (1976)							X	X	X			X	

Table 2

Part C (Pratt - Yancy)

	Availability of Mode	Reliability of Mode	Availability of Information	COSTS: General/Unspecified	COSTS: Fares	COSTS: Automobile ownership and operating	COSTS: Parking, tolls	COSTS: Other	TIME: Traveling	TIME: Waiting	TIME: Walking
Pratt, et al. (1977)					X	X	X	X			
Pulliam, et al. (1976)									X	X	X
Pun, Kidder (1976)				X					X		
Recker, Golob (1976)				X					X	X	X
Recker, Stevens (1976)			X		X	X				X	X
Reish, Surti (1972?)					X				X	X	X
Scardino, Kerpelman (1977)		X		X				X	X	X	X
Schimpeler Corradino (1974)			X		X				X		X
Sen, Benjamin (1979)	X		X	X	X	X	X				X
Smith (1970)									X	X	X
Talvitie (1973)					X	X		X	X	X	X
Talvitie, Kirshner (1978)					X	X		X	X		X
Tehan, Wachs (1972)											
Train (1978)				X					X	X	X
Transportation-Employment Project (1971)	X	X	X		X						
USDOT/UMTA (1973)			X								X
Vitt, et al. (1970)			X		X				X	X	X
Voorhees (1974)						X	X				
Wachs (1976)				X	X	X	X		X	X	X
Wegmann, et al. (1979)			X							X	X
Wigner (1973)					X	X			X		
Worcester (1969)			X		X				X		X
Yancy (1972)									X		

Table 2

Part C (continued)

	SCHEDULES					ROUTING				
	Frequency/Headways	Dependability	Hours of Service	Choice of Pickup Time	Flexibility	Areal Coverage	Proximity to Home	Proximity to Destination	Directness	Flexibility
Pratt, et al. (1977)	X					X				
Pulliam, et al. (1976)						X				
Pun, Kidder (1976)										
Recker, Golob (1976)		X		X					X	X
Recker, Stevens (1976)		X				X		X	X	X
Reish, Surti (1972?)	X									
Scardino, Kerpelman (1977)		X				X	X	X		X
Schimpeler Corradino (1974)	X	X	X			X	X	X		
Sen, Benjamin (1979)	X		X			X	X	X		X
Smith (1970)							X	X		
Talvitie (1973)										
Talvitie, Kirshner (1978)										
Tehan, Wachs (1972)										
Train (1978)	X									
Transportation-Employment Project (1971)	X	X				X	X	X		
USDOT/UMTA (1973)	X	X				X		X		
Vitt, et al. (1970)		X	X	X					X	
Voorhees (1974)										
Wachs (1976)		X								
Wegmann, et al. (1979)		X		X			X	X	X	X
Wigner (1973)										
Worcester (1969)								X	X	
Yancy (1972)										

Table 2

Part C (continued)

	CONVENIENCE						COMFORT, AMENITIES ON VEHICLES					(Continued next page)
	General/Unspecified	Simplicity of Use	Transfers	Parking	Traffic Congestion	Ease of Travel from Vehicle to Destination	General/Unspecified	Ease of Vehicle Entry, Exit	Seating: Availability	Seating: Comfort	Provision for Standees	Smoothness of Ride
Pratt, et al. (1977)												
Pulliam, et al. (1976)			X									
Pun, Kidder (1976)	X											
Recker, Golob (1976)			X		X				X	X		X
Recker, Stevens (1976)	X		X				X					
Reish, Surti (1972?)												
Scardino, Kerpelman (1977)	X		X						X	X		
Schimpeler Corradino (1974)	X		X						X			X
Sen, Benjamin (1979)	X		X	X			X					
Smith (1970)												
Talvitie (1973)												
Talvitie, Kirshner (1978)												
Tehan, Wachs (1972)												
Train (1978)			X									
Transportation-Employment Project (1971)			X									
USDOT/UMTA (1973)			X					X	X		X	
Vitt, et al. (1970)			X					X	X	X		
Voorhees (1974)				X								
Wachs (1976)			X	X			X		X			X
Wegmann, et al. (1979)							X	X	X	X		X
Wigner (1973)												
Worcester (1969)												
Yancy (1972)							X		X			X

Table 2

Part C (continued)

	COMFORT, AMENITIES ON VEHICLES (Continued)											
	Noise	Cleanliness of Vehicle	Temperature, Ventilation, Lighting	Crowding	Privacy	Acceptability of Fellow-Passengers	Ease of Meeting, Talking with Friends	Opportunity to Relax, Read	Availability of Radio	Space for Parcels	Space for Wheelchairs, Baby Carriages, etc	Courtesy/Attitude of Driver/Operator
Pratt, et al. (1977)												
Pulliam, et al. (1976)				X						X		
Pun, Kidder (1976)												
Recker, Golob (1976)	X		X	X	X		X	X				
Recker, Stevens (1976)					X	X				X		X
Reish, Surti (1972?)												
Scardino, Kerpelman (1977)	X		X	X	X	X	X			X		
Schimpeler Corradino (1974)		X	X									X
Sen, Benjamin (1979)		X			X	X						X
Smith (1970)												
Talvitie (1973)												
Talvitie, Kirshner (1978)												
Tehan, Wachs (1972)			X									
Train (1978)												
Transportation-Employment Project (1971)												
USDOT/UMTA (1973)										X		X
Vitt, et al. (1970)			X	X	X	X	X			X	X	
Voorhees (1974)												
Wachs (1976)	X		X						X	X		
Wegmann, et al. (1979)	X				X					X		
Wigner (1973)												
Worcester (1969)												
Yancy (1972)	X		X	X	X	X	X					

Table 2

Part C (continued)

	COMFORT, AMENITIES--OUT OF VEHICLE				SAFETY, SECURITY			PSYCHOLOGICAL, AESTHETIC			SOCIAL VALUES		
	Shelter from Weather	Pedestrian Traffic, Crowding	Convenience of Payment of Fare	Amenities at Stops, Stations	General/Unspecified	Protection from Crime	Safety from Accidents	Enjoyment/Pleasure in Using Mode	Sense of Autonomy, Independence	Appearance/Modernity of Vehicle/System	Social Status	Pollution	Fuel Conservation
Pratt, et al. (1977)													
Pulliam, et al. (1976)	X					X						X	
Pun, Kidder (1976)													X
Recker, Golob (1976)	X					X	X			X		X	
Recker, Stevens (1976)	X					X	X	X			X		
Reish, Surti (1972?)													
Scardino, Kerpelman (1977)						X	X			X			
Schimpeler Corradino (1974)	X						X						
Sen, Benjamin (1979)							X				X		
Smith (1970)													
Talvitie (1973)													
Talvitie, Kirshner (1978)													
Tehan, Wachs (1972)							X		X		X		
Train (1978)													
Transportation-Employment Project (1971)						X	X					X	
USDOT/UMTA (1973)	X	X	X					X					
Vitt, et al. (1970)	X		X					X		X			
Voorhees (1974)													
Wachs (1976)	X					X	X						
Wegmann, et al. (1979)	X		X	X						X			
Wigner (1973)													
Worcester (1969)	X												
Yancy (1972)													

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