Relationships Between Drivers' Attitudes Toward Alternate Routes and Driver and Route Characteristics

MARTIN WACHS, Research Associate, The Transportation Center, Northwestern University

A home-interview study was carried out in order to investigate the relationships between the reasons drivers cite for choosing a particular route rather than an alternate for a trip and the characteristics of the drivers and the alternative routes. In examining constrained responses in which people gave reasons for choosing a particular route for a trip, tests were made to determine whether the importance of the various reasons differed with the purpose of the trip. Principal components factor analysis was used to determine whether responses about different reasons for route choice were measuring the same or different underlying values. Respondent's attitudes were examined to determine whether they were influenced by the socioeconomic characteristics of the people or by the performance characteristics of the routes. Statistical explanation of the attitudes, in terms of driver and route characteristics, was approached by three methods: canonical correlation, multiple regression, and grouping techniques. The results of these analyses are presented, and conclusions are drawn regarding the dependence of attitudes toward route choice upon persons and route characteristics.

•THE traditional benefit-cost analysis of highway improvement projects includes four primary types of user benefits to be derived from highway improvements: (a) reduction in cost of vehicle operation, (b) reduction in accidents, (c) reduction in strain and discomfort, and (d) savings of time. The valuation of each of these elements is a difficult problem which has not been adequately solved.

Some maintain that the value of time should be equal to the wage rate, because it can be assumed that time saved in travel can be put to income-producing labor. AASHO recommends assigning a value of $1.55 per hour to the time saved due to a highway improvement, although there is no strong theoretical basis for the selection of this particular value. Similarly, safety is valued by multiplying the estimated reduction in fatal accidents per annum by "a round sum which represents the loss due to one death, 35 personal injuries, and 210 property damage accidents—the average ratio of these types." The round sum currently recommended is $89,000 per fatality (2).

There are doubts that the valuations of benefits described for highway improvements bear any close relationships to the perceptions of cost and value which may be held by the highway user (9). If this type evaluation is accepted, there are still some questions which remain unanswered. Should a single value for the rich and the poor be used, or for the person making a trip to shop and another making a trip to work? Should the value of 5 minutes saved in a 15-minute trip be the same as the value of 5 minutes

Paper sponsored by Committee on Urban Transportation of Persons (Costs) and presented at the 46th Annual Meeting.

saved in a 3-hr trip? Because time savings often amount to half of the benefits accruing from a highway improvement project, the arbitrary nature of the values used for time is particularly disturbing.

The aim of this study is to determine whether subjective statements made by drivers about their perception of values in a choice between alternative routes for a trip are systematic and consistent functions of the characteristics of the respondents and of the routes about which they respond. If systematic and consistent relationships are found to exist, it is hoped that this study will lead to a better understanding of personal perceptions of benefit, and of how these perceptions differ among people. Such understanding could lead to further consideration of these perceptions in the evaluation of existing and proposed criteria for selection among alternative projects.

HOME-INTERVIEW PROCEDURE

To obtain the information required to carry out the investigation, a home-interview form was constructed, tested, and revised. Constrained-response type questions were used for the collection of most of the information and to facilitate the quantitative analysis of the data. Constrained-response questions often reflect the views and attitudes of the person constructing the interview form, and thus tend to introduce bias into the results obtained. Therefore, about 20 pilot interviews were conducted to minimize bias. These consisted of open-ended questions; the constrained-response questions were constructed only after a careful study was made of the answers to the open-ended questions. Every effort was made to word the questions in a neutral manner, and to incorporate the points raised by the respondents in the open-ended pilot interviews. In addition, some redundancy was introduced into the final questionnaire form by including both open-ended and constrained-response questions on several issues. The comparison of the responses to the two types of questions revealed how the respondents interpreted some of the key words used in the constrained-response questions.

During the interview, information was obtained about the factors which the respondent considered important in the choice of routes for a trip to work, a trip to shop for clothing, and a trip to visit a friend. In addition, detailed information about the socioeconomic and demographic characteristics of the respondent was obtained. The respondent was also asked to draw, on a map supplied by the interviewer, the routes which he perceived as possible alternates for his trip to work. This enabled the gathering of detailed information about the characteristics of these routes which was necessary for the analysis. No data were gathered about the routes actually used in the trip to visit a friend or to shop for clothing, because this would have made the interview too lengthly for the respondents, and because the author's time constraints would have made thorough analysis of the information impossible.

A sample of several hundred potential subjects was drawn from the R. L. Polk and Company's 1963 directory for Evanston, Illinois. Prospective subjects were first mailed a letter which explained the purposes of the research and the nature of the interview. About one week after mailing the letter, subjects were telephoned in order to make an appointment for the interview. About 20 percent of the people in the sample had moved, died, or had become otherwise unreachable since 1963. Thirty-five percent of the people to whom letters were sent refused to cooperate, the remaining 45 percent agreed to participate and were consequently interviewed. The refusal rate in the nonwhite neighborhoods was approximately 10 times the refusal rate in the white areas. In addition, the women contacted refused to participate about twice as often as the men. As a result, the sample is biased toward white males as compared with a truly random sample of the population of Evanston.

Of the respondents interviewed, 21 percent were women and 79 percent were men. The mean age of the respondents was 49 years, although they ranged in age from 19 to 78 years. Household sizes varied from one to 8 persons, with a mean value of 3 persons per household. The average level of education among the subjects was 14.7 years, with the lowest level being 6 years, and the highest being 20 years. Twelve percent of the interviewees were engaged in blue-collar occupations, 72 percent were in white-collar but nonprofessional positions, and 16 percent were professionals. The sample

had a mean family income of approximately $14,800 per year, and 65 percent of the respondents owned their own homes, whereas 35 percent rented houses or apartments. About 85 percent of the respondents had moved to their present homes from others in the Chicago Metropolitan Area, while 15 percent had come from outside the metropolitan area. The average family had lived at its present address for a little more than 9 years. Only 35 percent of the sample, however, was born in the Chicago Metropolitan Area. Approximately 43 percent of the respondents worked in the CBD of Chicago, and they had an average trip to work which took 28 minutes and covered 9.7 miles. The trips varied, however, from a few blocks in length to a 65-minute journey to work.

This brief profile indicates that the responses measured are those of the citizens of a stable upper-middle-class commuter suburb with a lower proportion of home owners than most typical commuter suburbs. The members of the community are relatively well educated. The characteristics of the respondents should be borne in mind by the reader, because the measurements made and the relationships found can be assumed to be valid only over the ranges of the variables actually observed in the sample. Although it was a pilot study, it was useful nonetheless for testing methods of analysis and for formulating hypotheses regarding the interactions between the variables measured. It cannot be concluded that other groups of people would respond in a similar manner, although the methods of analysis proposed would certainly be applicable to other respondents.

Lower limits on the reliability of all constrained-response questions were computed according to the method devised by Guttman (8). The mean lower limit found was 0.47, and since this method yields an extremely conservative lower bound, the survey items have been taken to be reliable measurements of the attitudes and responses of the persons interviewed.

DIFFERENCES IN ATTITUDES WITH TYPE OF TRIP

Twenty-one constrained-response questions were given to each respondent to determine which characteristics of the alternative routes were important in his choice of a route for his trip to work. The same questions were repeated for a trip to "visit a friend," and another for "shop for clothing." Table 1 gives a listing of the statements. The respondent circled number 4 if the statement represented a very important factor in his choice of a route, 0 if the factor was very unimportant, and a number between the extremes if his feelings were better represented by such a response. The ordering of the statements was changed with each trip type to minimize the recollection of previous answers. Because the responses were ordinal in nature, a psychological-scaling method, based on the law of categorical judgment, was used to convert these responses to values which could be operated on as interval and ratio scales, and thus to facilitate some of the quantitative analysis which follows (6).

To determine whether the responses to each of the statements about route choice were distributed similarly or differently for each of the three trip types, the nonparametric Kolmogorov-Smirnov two-sample test was employed (15). Table 2 shows that for 14 of the 21 attitude variables considered, the null hypothesis that there was no difference between the distributions of attitudes among trip types could not be rejected at the 99 percent level of confidence. Safety, however, was significantly more skewed toward the important end of the scale for route choice in visit trips than in work trips; the same is true for pleasant scenery, pavement smoothness, and less hilliness. Although trip time, less congestion, and absence of stops and interruptions received the highest mean scores for all trip types, the results indicate that safety, scenery, and pavement smoothness are considered more important for visit trips than they are for work trips. This perhaps indicates the businesslike nature of the work trip as compared to the more leisurely nature of the visit trip. In the former, getting to the destination promptly is the most important criterion, but the latter enables the driver to consider other factors related to the pleasure of driving on a safe, smooth, scenic route.

The responses for the presence of more stores, service stations, and restaurants as a factor in route choice were more skewed toward the unimportant end of the scale

TABLE 1

LIST OF STATEMENTS ABOUT REASONS FOR ROUTE CHOICE

Statement	Scale (Very Important → Very Unimportant)
I choose the route I use most frequently to drive to work because:	
It costs me less to drive on that route than it does on others.	4 3 2 1 0
There is greater safety on that route than there is on others.	4 3 2 1 0
There is less congestion on that route than there is on others.	4 3 2 1 0
The distance is shorter along that route than it is along others.	4 3 2 1 0
The road is less hilly along that route than it is along others.	4 3 2 1 0
There are fewer turns along that route than there are along others.	4 3 2 1 0
The trip takes less time along that route than it does along others.	4 3 2 1 0
There are fewer traffic signals along that route than along others.	4 3 2 1 0
The scenery is more pleasant along that route than it is along others.	4 3 2 1 0
There is greater visibility of what is ahead along that route than along others.	4 3 2 1 0
There are more lanes on that route than on others.	4 3 2 1 0
There is less strain and discomfort to driving on that route than on others.	4 3 2 1 0
There are fewer stops and interruptions to driving on that route than on others.	4 3 2 1 0
There are fewer trucks and buses on that route than there are on others.	4 3 2 1 0
The pavement is smoother on that route than it is on others.	4 3 2 1 0
There are fewer full-stop signs on that route than there are on others.	4 3 2 1 0
The route is less curvy than others.	4 3 2 1 0
The lanes are wider than on other routes.	4 3 2 1 0
There are more stores, service stations, and restaurants than along other routes.	4 3 2 1 0
There are fewer stores, service stations, and restaurants than along other routes.	4 3 2 1 0
There are fewer pedestrians crossing along that route than along others.	4 3 2 1 0

for the work and visit trips than for the shopping trip; whereas the presence of fewer stores, service stations, and restaurants was more important in the trip to work than in other trip types. These responses, together with comments from the respondents during the course of the interviews, seem to indicate that many people do not mind the congestion and delay associated with commercial development, if the purpose of their trip is to use the services of the establishments. Many said that they liked to pass stores on a shopping trip because it made them aware of possible alternate destinations. On the other hand, commercial development, and the traffic characteristics

TABLE 2

RESULTS OF KOLMOGOROV-SMIRNOV TEST OF SIGNIFICANCE OF DIFFERENCES BETWEEN TRIP TYPES IN ATTITUDES TOWARD ROUTE CHOICE[a]

Attitude Variable	Trip-Type Pairs		
	Work-Visit	Work-Shop	Visit-Shop
Costs less	No	No	No
Greater safety	Yes	No	No
Less congestion	No	No	No
Distance shorter	Yes	No	No
Less hilly	Yes	Yes	No
Fewer turns	No	No	No
Less time	No	No	No
Fewer traffic signals	No	No	No
Scenery more pleasant	Yes	No	Yes
Greater visibility	No	No	No
More lanes	No	No	No
Less strain and discomfort	No	No	No
Fewer stops and interruptions	No	No	No
Fewer trucks and buses	No	No	No
Pavement smoother	Yes	No	No
Fewer full stops	No	No	No
Less curvy	No	No	No
Lanes wider	No	No	No
More stores, service stations, etc.	No	Yes	Yes
Fewer stores, service stations, etc.	No	Yes	No
Fewer pedestrians	No	No	No

[a]Yes indicates significant difference. No indicates no significant difference (level of significance = 99%).

it brings, seems to detract from the directness sought in the work trip and the relaxation sought in the visitation trip.

The importance of choosing a route with shorter distance than other routes was distinctly bimodal for work trips with very important responses only slightly more numerous than very unimportant responses. For visit trips, however, distance did not display such a bimodal distribution. An open-ended question asking the respondent what factors he thought affected travel time on a route showed that many associated trip time with trip distance, and others associated trip time with congestion rather than distance. This may help to explain the bipolar response to the distance variable for the work trip, in which undelayed access to the destination is apparently more important than it is for other trip types.

Factor Analysis of Work-Trip Attitudes

The list of route characteristics which were considered and rated by the respondents contains some statements that are redundant and overlapping with others on the list. For example, the statement that "there is less congestion on that route than there is on others" and the statement that "there are fewer stops and interruptions to driving on that route than on others" may mean the same thing to those drivers who perceive congestion as interference with uninterrupted driving along a street or highway. It would have been impossible to eliminate this redundancy on an a priori basis before the questionnaire was administered, because driver perceptions of the interrelationships were not known at that time. Because many of the 21 attitudinal measurements may actually be measures of the same or similar underlying values as others, an attempt was made to reduce this redundancy in the matrix of measurements. In order to accomplish this, a rotated principle components factor analysis (5, 10) was performed on the matrix of scaled responses to the statements about route choice. This technique serves to isolate independent dimensions of attitudes toward route choice; the set of factor loadings obtained is extremely instructive in that it enables one to examine the interrelationships among the responses to the 21 variables. Reduction of the

TABLE 3

WORK-TRIP ROUTE CHOICE ATTITUDE FACTORS AND FACTOR LOADINGS

Factor Number	Percent of Variance	Loading	Factor Name and Variable Names
1	26.5		Preference for Access Controlled Routes
		+0.765	More lanes on this route than on others
		+0.733	Fewer full-stop signs on this route than others
		+0.721	Lanes wider on this route than on others
		+0.606	Fewer traffic signals on this route than others
		+0.563	Fewer stops and interruptions to driving on this route than others
		+0.521	Fewer pedestrians crossing along this route than along others
		+0.513	Pavement smoother along this route than others
2	9.4		Preference for Less Congestion and Strain
		-0.821	Less congestion on this route than on others
		-0.607	Less strain and discomfort to driving on this route than others
		-0.593	Fewer trucks and buses on this route than others
		-0.514	Fewer stops and interruptions to driving along this route than along others
3	8.5		Preference for Safety
		+0.695	Greater safety on this route than others
		+0.638	Fewer turns along this route than along others
		+0.632	Route is less curvy than others
		+0.612	Route is less hilly than others
		+0.570	Greater visibility of what lies ahead on this route than on others
4	7.4		Preference for Shortest Route
		+0.780	Distance is shorter along this route than along others
		+0.677	Trip takes less time along this route than along others
		+0.603	Trip costs less along this route than along others
5	5.6		Preference for Commercial Development Along Route
		+0.903	More stores, service stations, and restaurants along this route than along others
6	5.1		Preference for Pleasant Scenery
		+0.772	Scenery is more pleasant along this route than along others
7	4.5		Preference for Absence of Commercial Development Along Route
		+0.753	Fewer stores, service stations, and restaurants along this route than along others
		+0.454	Fewer pedestrians crossing along this route than along others
		+0.449	Fewer trucks and buses along this route than along others

matrix to fewer orthogonal dimensions also makes the attempts at statistical explanation of attitudes reported later more manageable and more interpretable. Factor analyses were performed separately on responses about work trips, shopping trips, and visit trips. Since the results for the three trip types were essentially similar, and since quantitative data for the characteristics of the work trips only were gathered, the results of the factor analysis for this trip type only are reported here.

The factor analysis resulted in reduction of the 21 attitudinal variables for work trips to 7 orthogonal factors, which account for 67 percent of the variance in the original variables. Because the matrix of factor loadings reveals the interrelationships between the attitudinal variables, it is most instructive. Table 3 gives the 7 factors along with the variables which load heavily upon them and their factor loadings. The names assigned to these independent factors represent an interpretation of the meaning of the common nature of all the variables loaded heavily on each factor. The factors are, in order of variance which they "explain": preference for access controlled routes, preference for less congestion and strain, preference for safety, preference for the shortest route, preference for commercial development along a route, preference for pleasant scenery, and preference for absence of commercial development along a route. The 7 factors can be taken as being representative of the entire matrix of attitudinal responses, since they explain such a high proportion of the total variance.

The validity of the factors may be judged, to a great extent, by the subjects' responses to the open-ended questions. Factor 2, for example, shows that congestion, strain and discomfort, the presence of trucks and buses, and stops and interruptions along a route are perceived as being positively related to one another. The unconstrained-response question, asking what caused strain and discomfort when driving, elicited frequent answers of "heavy congestion," "stop and go driving," "bumper-to-bumper traffic," and "trucks and buses." The parallel between the responses to this question and the composition of factor 2 is impressive. Similar open-ended statements relate to other factors and lend confidence to the use of the 7 factors as true measures of driver attitudes.

At first glance, factor 5 and factor 7 appear to be inversely related, and hence their logical independence is subject to question. Although it would be inconsistent for a subject to rate both of these as important considerations in the choice of a route, there is no inconsistency in listing both as unimportant factors. Some respondents considered one important, others listed the other as being important, and some considered neither factor important, thus allowing the analysis to give the result of independence.

Relationships Between Attitudes Toward Route Choice and the Characteristics of the Respondents and Their Routes

It is hypothesized that a person's attitudes toward what is important in the choice of a route are dependent on the characteristics of the person and the nature of the trip, and the characteristics of the alternative routes available. This hypothesis is tested in this section, and attempts are made to quantify the functional relationships between the measured attitudes and the personal as well as trip characteristics of the respondents. These relationships are examined in three ways. First, canonical correlation coefficients are computed to test for significant relationships between the attitudes and the socioeconomic and demographic characteristics of the respondents, and between the attitudes and the trip characteristics. Second, multiple regression is used to express each of the 7 attitude factors as a function of the socioeconomic, demographic, and trip characteristics. Finally, a grouping analysis is performed to determine whether groups of respondents with distinct attitude patterns also display distinct patterns of socioeconomic or trip characteristic data.

The 18 socioeconomic and demographic variables which were measured for each respondent are given in Table 4. Note that some are continuous, some dichotomous (yes, no), and some ordinal. This fact had an important effect on the analysis which will be described later.

TABLE 4

SUMMARY OF SOCIOECONOMIC AND DEMOGRAPHIC VARIABLES MEASURED FOR EACH RESPONDENT

Respondent's sex (male, female)
Respondent's age, years
Respondent's race (white, nonwhite)
Size of respondent's household, people
Respondent's occupation (blue collar, white collar nonprofessional, professional)
Education of respondent, years
Number of drivers in respondent's household
Time respondent lived at present address, years
Time respondent lived at previous address, years
Previous address location (in Chicago metropolitan area, outside Chicago metropolitan area)
Place of birth of respondent (in Chicago metropolitan area, outside Chicago metropolitan area)
Home ownership status (own, rent)
Respondent's time on present job, years
Respondent's family income, thousands/year (11 categories)
Respondent's family car ownership
Type of residence (one family detached, one family row, two family, apartment)
Number of miles driven by respondent in previous year, thousands
Stage in family life cycle (6 categories based on age, marital status, and number of children)

In order to gather information about the characteristics of the work trip and the alternative routes perceived by the trip-maker, two supplementary approaches were used. First, questions were included in the interview about the nature of the trip and the alternative routes. In addition, the respondent indicated by marking on a detailed street map of Chicago, exactly what his alternative routes were. This enabled the gathering of quantitative information about the routes which could not be obtained directly from the home interview. Before presenting this data, however, a digression is necessary to describe the appropriateness and limitations of the data used.

Most of the respondents spoke of two alternative routes for their trip to work, although some cited as many as six or seven. In order to keep all the responses comparable to one another, the data actually used in this phase of the analysis were confined to two route alternatives—the preferred and second-best routes—for all respondents. The travel time used for each route was the respondent's estimated travel time. In order to measure actual travel time, the researcher would have had to traverse each route several times at the same time of day that each respondent made his work trip. This was not possible. The respondent's trip-time estimate is taken as a true measure of trip time, since respondent's estimates of trip distance and trip distances scaled off the maps were correlated by more than 0.9, and a driver is assumed to be more apt to look at his wristwatch than his odometer.

Traffic volumes on the routes were obtained from the Chicago Bureau of Street Traffic. Average daily volumes were multiplied by an hourly proportion to estimate volumes during the hour in which the respondent made the trip. Average volumes for a route are the result of weighting the volume on each portion of each route by the length of that portion. A serious limitation here is that the volume of traffic on a street or highway is not a true measure of its performance or traffic characteristics. A given volume on an arterial street might indicate congestion, whereas the same volume on a freeway might indicate free-flow conditions. The ratios of volume to capacity would have been more meaningful than volumes alone, but unfortunately design capacities were not available and therefore could not be used.

Two homemade sets of measurements on the routes were employed because better ones were not available. The number of intersecting arterials along each route was counted and included as a surrogate for delay and interrupted driving. The number of segments in a route was defined as the number of continuous portions of a route, each along a particular street or highway. This is, perhaps, a measure of the directness of a route. Clearly, the characteristics of the routes which are used in the analysis

are inadequate to completely specify the nature and performance level of the alternatives. Nevertheless, in the absence of more useful data, these allowed us to make the preliminary and exploratory investigations presented here.

Table 5 gives a listing of the trip and route characteristics used in the study of the relationships just described. Rather than presenting a characteristic, such as traffic volume, for both the preferred and alternate routes, the actual value of the characteristic is shown for the preferred route, along with the ratio of the value of the characteristic on the preferred route to the value on the alternate route. This is done because attitudes may be related to both the absolute magnitude of the measured characteristic, and to the relative magnitudes among the alternatives. For example, if trip time is a variable which influences one's choice between routes, this choice might be influenced by both the absolute trip length (is it a 15-minute trip or a one-hr trip?) and the relative trip lengths among the alternative routes (is route A 5 minutes quicker than route B?). The use of the absolute value on the preferred route and the ratio of the value on the preferred to the value on the less preferred route seems to be the most reasonable method of capturing these two types of influences.

The hypothesis that the stated attitudes could be related to the characteristics of the respondents and their trip and route characteristics was first tested by computation of the canonical correlations between the sets of variates. Canonical correlation coefficients for sets of variables may be interpreted in much the same manner as is the product-moment correlation coefficient for a pair of variables (5, 11). Figure 1 shows the canonical correlation coefficients between the original sets of variables, and between the work-trip factors and the other two sets of variables (21 work-trip characteristics were used rather than the 24 given in Table 5 because of the obvious logical redundancy in some of them). The level of significance of these coefficients, computed according to Bartlett's method (1), is shown in parentheses for each coefficient. The coefficients for the work-trip attitude factors are lower than those for the raw variables because a portion of the variance in this set of variates has been eliminated, and because the number of degrees of freedom has been changed. The coefficients do indicate that there are strong relationships between the sets of variables, that these relationships are statistically significant, and that there is reason to further explore these relationships.

TABLE 5

SUMMARY OF WORK-TRIP AND ROUTE CHARACTERISTICS MEASURED FOR EACH RESPONDENT

Number of alternate routes cited
Percent of time using modes other than driving
Percent of time using preferred route
Percent of time using alternate route
Travels to work alone? (yes or no)
Uses car at work? (yes or no)
Trip made during peak hour? (yes or no)
Trip time, minutes, preferred route
Trip to CBD? (yes or no)
Distance on local streets, miles, preferred route
Distance on arterials, miles, preferred route
Distance on expressways, miles, preferred route
Total distance, miles, preferred route
Number of segments, preferred route
Number of intersecting arterials, preferred route
Average traffic volume, veh/hr, preferred route
Volume ratio (preferred route/alternate route)
Distance on local streets ratio (preferred route/alternate route)
Distance on arterial streets ratio (preferred route/alternate route)
Distance on expressways ratio (preferred route/alternate route)
Total distance ratio (preferred route/alternate route)
Travel time ratio (preferred route/alternate route)
Segments ratio (preferred route/alternate route)
Intersecting arterials ratio (preferred route/alternate route)

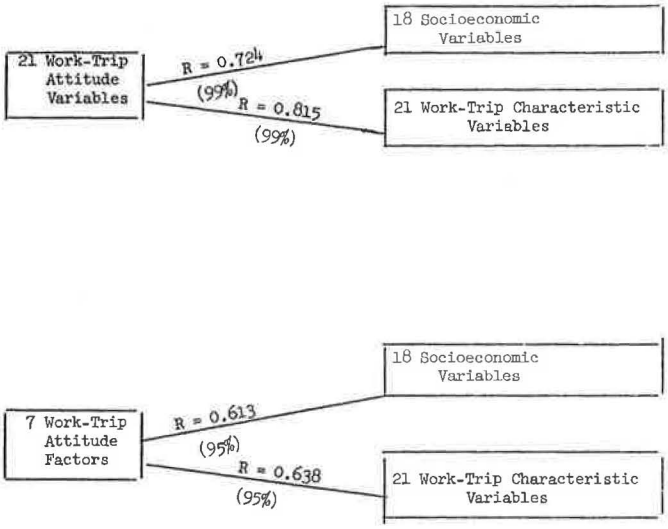

Figure 1. Canonical correlation coefficients between work-trip attitude variables and socioeconomic and trip characteristic variables, and between work-trip factors and socioeconomic and trip characteristic variables.

Multiple stepwise linear regression is the tool selected for use in the attempt to more closely scrutinize the relationships between the individual work-trip attitude factors and the driver's socioeconomic, demographic, and route characteristics. The multiple stepwise regression method, in its basic form, is restrictive in that it assumes a linear relationship between the dependent variable and each independent variable. Although transformations of the data and the use of nonlinear regression are ways to avoid this problem when necessary, they often become involved and too often reduce the interpretability of the results. The method employed here, called the dummy variable technique, allows the consideration of independent variables whose relationship to the dependent variable need be neither linear nor monotonic (17). The method permits the inclusion of independent variables which are continuous but which are not linearly related to the dependent variable, and also enables one to include qualitative or nominal variables, such as sex or occupation. The independent variable to be included in this manner is stratified into several discrete classes, each containing a particular value or range included in the original variable. Each class, except one, becomes a single dummy variable which takes on a value of unity if an observation falls in that class. The dummy variables representing the remaining categories each take on the value of zero. If the excluded category is the one into which the observation falls, all dummy variables representing that original variable become zero. Morgan has shown that a single standardized regression coefficient (beta coefficient) may be found for the set of dummy variables representing a single original variable (14). This beta coefficient, except for the fact that it has no meaningful sign, is interpretable as is the beta coefficient for a continuous linear variable, and may be compared to similar coefficients for linear variables and other dummy variables in the same regression equation.

Seven regression equations were computed, using each of the seven attitudinal factors as dependent variables. The independent variables used in each equation are the result of several trials in which all variables were at first represented as dummy variables, and then those which displayed a linear relationship with the dependent variables were replaced by the original continuous variable. Thus, each of the equations includes some linear and some dummy variables. Approximately 30 original independent variables were used in each equation. Although his number is large, they were all included in the final runs to allow inclusion of all the dummy variables asso-

ciated with a given original variable. Since a stepwise regression program was used, in many cases a dummy variable entered in an early step, while other dummy variables associated with the same original variable entered much later—perhaps after the inclusion of several less significant linear variables.

In order to save space, only summary tables (Tables 6 to 12) showing the few independent variables which most strongly influenced each of the dependent variables are included in this report. The criterion for their selection is the magnitude of their beta, or standardized regression coefficients. Coefficients of determination (R^2) ranging from 0.36 to 0.58 were found for the seven regressions in their complete form.

Examination of Tables 6 through 10 indicates that the travel time for the trip to work appears among the few most important independent variables for five of the seven attitude factors. Thus, we may infer that the duration of the work trip has a strong influence on the factors considered important in the selection of a route for that trip from possible alternate routes. The respondents showed a general tendency, as trip time increased, toward (a) increasing preference for access control; (b) increasing preference for less congestion and strain; (c) increasing preference for safety; (d) decreasing preference for the shortest route; and (e) decreasing preference for the absence of commercial development along the route. The first three tendencies indicate an increasing importance attached to perceived performance levels of routes as trip length increases. The fourth indicates that one might be willing to sacrifice directness in order to choose a route of higher performance characteristics, and may also lead one to hypothesize that the perceived value of a time saving of given duration decreases as the total trip time increases. The fifth item is difficult to explain, and may even contradict the previous reasoning.

Table 6 shows that preference for access control is strongly associated with the number of intersecting arterials along the route—a measure of the lack of access control. People expressing strong preferences for access control were found to be using routes which tended to have fewer intersecting arterials. In addition to the number of intersecting arterials and the travel time, some socioeconomic and demographic variables have a rather strong relationship with preference for access control. Older people seem to display less of a tendency toward preference for access control than younger people—one might guess that this is related to the fact that older respondents grew up and learned to drive before freeways were available. This might indicate that as our population ages, and those born since the inception of freeways become the dominant proportion of the driving public, there will be more of a tendency toward use of access controlled facilities. Preference for access control was also found to decrease with increasing educational level, and to tend to increase with length of residence at the respondent's present address. One can see no logical explanation for the relationship between preference for access control and family size. Peak-hour travelers showed stronger preferences for access control than off-peak drivers, perhaps because of the congestion and delay associated with clogged arterial streets during rush hours.

TABLE 6

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 1[a]

Independent Variable	Linear	Dummy	β
Number of intersecting arterials	x		0.496
Years of education		x	0.389
Travel time, minutes		x	0.373
Years at present address		x	0.367
Family size?		x	0.362
Age, years		x	0.352
Trip made in peak hour?		x	0.302

[a]Dependent variable: preference for access controlled route.

TABLE 7

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 2[a]

Independent Variable	Linear	Dummy	β
Travel time, minutes		x	0.361
Distance on arterial streets, miles	x		0.352
Trip to CBD?		x	0.323
Years at present address		x	0.308
Number of segments in route	x		0.271

[a]Dependent variable: preference for less congestion and strain.

Table 7 shows, as mentioned before, that preference for less congestion and strain in the work trip tended to increase with increasing trip length for the sample of respondents. People who expressed higher preferences for less congestion and strain seemed to be satisfying these preferences to some degree because their route choices tended to have shorter distances on arterial streets, and fewer "segments" in their routes. People who traveled to the CBD, where driving is likely to be hectic, showed lower preference for the absence of congestion and strain than did people whose destinations were elsewhere. Since the CBD is more likely to be congested than other parts of the city, this too indicates that the respondents' preferences are perhaps being satisfied to some degree by the existing highway network. Tenure of residence (a variable which is strongly correlated with age) also influenced preference for less congestion and strain, although the relationship was not monotonic.

In addition to becoming a more important reason for route choice as travel time increases, safety (Table 8), becomes more important as the ratio of the number of intersecting arterials on the respondent's preferred route to the number on his alternate route decreases. Holding other variables constant, people born outside the metropolitan area were more concerned with safety than those who were born and raised in close proximity to the bustling transportation network. Blue-collar workers and professionals rated safety as being more important in their choice of a route than did white-collar workers; lower and higher income people showed the same tendency with respect to middle-income people. Respondents who had been on their present job for a shorter period of time listed safety as being more important than those on their jobs for a longer period of time. Perhaps we might hypothesize that the former were more wary of safety because of their lack of familiarity with the alternatives than the latter.

Table 9 indicates that preference for the shortest route is most strongly affected by the average traffic volume on the route. As one might expect, increasing traffic volumes lead to increasing preference for the shortest route. Once again, travel time has a significant influence on the perceived importance of the factor in the route-choice decision. It is also interesting to note that the frequency with which the respondents use transportation modes other than driving also influences their preference for the shortest route. In general, those who drive most often place greater importance on

TABLE 8

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 3[a]

Independent Variable	Linear	Dummy	β
Intersecting arterials ratio	x		0.424
Born in Chicago metropolitan area?		x	0.423
Travel time, minutes		x	0.405
Occupation		x	0.382
Income, thousands		x	0.306
Years on job	x		0.254

[a]Dependent variable: preference for safety.

TABLE 9

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 4[a]

Independent Variable	Linear	Dummy	β
Average traffic volume, 100 veh/hr	x		0.562
Travel time, minutes		x	0.405
Percent of time using other modes		x	0.395
Age		x	0.307
Number of drivers in household	x		0.300
Ratio of distances on expressways	x		0.257

[a]Dependent variable: preference for shortest route.

seeking the shortest route than those who drive less often. With other variables held constant, as the ratio of expressway distance on the preferred route to expressway distance on the less preferred route increases, the preference for the shortest route decreases. This perhaps indicates that as the performance level of the preferred route becomes relatively better, one is willing to sacrifice directness in order to achieve the higher level of service. The respondent's age, and the number of drivers in his household have strong but non-monotonic effects on preference for the shortest route.

Table 10 shows the independent variables which most strongly influence the respondents' stated preference for commercial development along the routes which they choose for their trips to work. Drivers who used other modes of transport either very frequently or very infrequently showed lower preference for commercial development along their routes than others. Those who drove more, as indicated by the mileage they had driven last year, tended to show less preference for commercial development along their routes. As income increased, preference for commercial development along the routes tended to decrease, perhaps because the upper socioeconomic groups are less tolerant of delay than others. Again, the author can see no clear-cut logical justification for the importance of family size as an influence on preference for commercial development along the respondents' routes.

Preference for pleasant scenery along a route is apparently associated most strongly with the respondent's family size, tenure of residence, frequency of taking other modes, and social status, as indicated by income and education (Table 11). Unfortunately, the meanings of these relationships are difficult to interpret because they are all non-monotonic and lacking in clear-cut trends. Perhaps the grouping analysis which follows the regression results will shed more light on the nature of these relationships.

Table 12 shows the independent variables which were found to influence most strongly the respondents' preferences for the absence of commercial development along the routes which they chose for their trips to work. Drivers with longer trips tended to display less preference for the absence of commercial development than did those with shorter trips. More educated respondents showed lower preference for this factor than did those with less education. As the distance traveled on expressways by the respondents increased, so did their preference for absence of commercial development,

TABLE 10

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 5[a]

Independent Variable	Linear	Dummy	β
Percent of time using other modes		x	0.762
Years at present address		x	0.458
Family size		x	0.377
Miles driven last year		x	0.313
Income, thousands		x	0.284

[a]Dependent variable: preference for commercial development along route.

TABLE 11

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 6[a]

Independent Variable	Linear	Dummy	β
Family size		x	0.493
Years at present address		x	0.405
Percent of time using other modes		x	0.361
Income, thousands		x	0.294
Educational level		x	0.284

[a]Dependent variable: preference for pleasant scenery.

TABLE 12

SUMMARY OF REGRESSION ANALYSIS OF WORK-TRIP ATTITUDE FACTOR NUMBER 7[a]

Independent Variable	Linear	Dummy	β
Travel time, minutes		x	0.493
Years of education		x	0.406
Family size		x	0.309
Distance on expressways, miles	x		0.300
Total distance ratio (pref./less preferred)	x		0.217

[a]Dependent variable: preference for absence of commercial development along route.

again perhaps indicating that the routes selected did tend to display the desired characteristics. As the ratio of total distance on the preferred route to distance on the less preferred route increased, preference for absence of commercial development was found to decrease.

Although many of the findings of the regression analysis are interesting and have logical explanations, many are difficult to interpret. The strong relationships which appeared to exist between the work-trip attitude factors and the sets of socioeconomic and work-trip characteristics based on the canonical correlations are apparently quite difficult to quantify in terms of individual factors and variables. Although many of the regression results allow interesting logical explanations, a few of the relationships, such as the ones between family size and several attitude factors, defy explanation on logical grounds. First, another method of examining the interrelationships between the attitudes and the socioeconomic and work-trip characteristics will be examined, because it may lead to some conclusions which will help to extend those based on the given analysis.

The final method employed in the examination of the interrelationships between work-trip attitude factors and socioeconomic and work-trip characteristic variables was a grouping technique. The respondents were grouped so that those within groups were homogeneous in their attitudinal responses, and so that the groups differed in their patterns of attitudinal responses. Then, comparisons were made between the groups in terms of their socioeconomic, demographic, and work data to see how the attitudinal groupings differed in these characteristics.

The grouping technique had two stages. First, a correlation matrix was computed, showing the correlation between each of the 139 respondents (treated as variables) and all other respondents, with the factor scores on each of the seven attitudinal factors treated as observations on each respondent. Second, a simple linkage analysis was performed on this correlation matrix to isolate groups of respondents who were strongly related to one another (12). The groupings obtained in the linkage analysis were then used as inputs into a discriminant iterations procedure (3), in which discriminate functions were found, and group membership probabilities for each respondent's membership in each group were calculated. If a respondent had a higher probability of belonging

TABLE 13

SUMMARY OF COMPOSITION OF GROUPS FORMED BY LINKAGE ANALYSIS AND DISCRIMINANT ITERATIONS

Group 1
High preference for less strain and congestion
High preference for pleasant scenery
Low preference for shortest route
Oldest group
Longest average trip length
Largest number of trip segments
Highest ratio of dist. (pref.)/dist. (less pref.)
Highest ratio of segments (pref.)/segments (less pref.)
Longest average distance on arterials
Group 2
Low preference for less strain and congestion
Greatest preference for safety
Least preference for absence of commercial development along route
Shortest average trip length
Smallest prop. of work trips to CBD
Smallest average distance on expressways
Smallest average traffic volume
Lowest average income
Group 3
High preference for access control
Low preference for safety
Low preference for commercial development along route
Youngest group
Highest proportion of males
Most mobile group (apt. dwellers short time pres. address, high prop. previous address outside CMA)
Low number of intersecting arterials
High mileage driven last year
High proportion of CBD trips
Small average distance on local streets
Group 4
Low preference for safety
High preference for shortest route
High preference for pleasant scenery
Large proportion of professionals/high income
Highest average level of education
High proportion of home owners
High proportion of CBD trips
Frequent use of other modes
Small number of trip segments
Group 5
High preference for shortest route
High preference for commercial development along route
Low preference for pleasant scenery
Highest proportion of females
Low educational level
Highest proportion of blue-collar workers
Long expressway distance
High proportion of off-peak travelers
Low distance on arterials
Group 6
Low preference for access control
High income
High average age
High educational level
Longest average distance on local streets
Shortest average distance on expressways
Low proportion of trips in peak hour
High ratio of intersecting arterials (pref.)/(less pref.)
High ratio of segments (pref.)/(less pref.)
Small proportion of respondents using car for work

to a group other then the one to which he was assigned, he was shifted to the group of higher probability, and the process was repeated. After six iterations the respondents were all found to be in the groups to which they had the highest probability of belonging. The resulting six groups are given in Table 13, which lists the attitudes and characteristics that are distinctive to each group.

Careful study of Table 13 shows many consistencies with the results of the regression analysis, but a few inconsistencies as well. The influence of increasing trip length on preference for higher levels of service, which was found in the regression analysis, seems to be upheld, to a high degree, by the composition of the groups. Thus in group one, high preference for less strain and congestion and strong preference for pleasant scenery are associated with the group that has the longest average trip length; group 2, the group with the shortest average trip length, displays the least preference for less strain and congestion, and the least preference for the absence of commercial development from its routes in the trip to work. The group with the highest preference for safety, however, is the one with the shortest trip length, and this finding contradicts the positive association between trip time and safety found in the regression analysis.

The regression finding that the respondents' preference for access controlled routes is strongly related to their age is also corroborated by the grouping analysis. Group 3, with the youngest average age of the six groups, has the highest preference for access control; group 6, with a high-average age, exhibits the least preference for controlled access among the groups. An interesting finding, which is consistent with accident statistics and auto insurance rates, is that the youngest group showed the least preference for safety in its choice of routes for its trips to work. A surprising finding is that the groups with the highest mean level of education and the highest proportion of professionals also found safety relatively unimportant.

The reader will recall that the regression results indicated that drivers' route choices tended to be in equilibrium with their attitudes. Drivers who preferred access control tended to make trips with higher proportions of their distances on expressways than on arterials, and on routes with fewer intersecting arterials than others. Drivers who expressed a low preference for the shortest route in their trip to work were using routes which were longer, with respect to their alternates, than drivers who expressed a strong preference for the shortest route. This finding of apparent equilibrium is upheld to some extent by the grouping analysis. For example, group 6 demonstrated a low preference for access control and the shortest average distance on expressways, the longest average distance on local streets, and the highest ratio of intersecting arterials on the preferred route to intersecting arterials on the alternate route. Group 3, with high preference for access control, demonstrated a low usage of local streets in its trips to work. Group 2, with the least preference for the absence of commercial development along its routes, had the smallest average distance on expressways.

Preference for pleasant scenery along the route to work was found, in the regression analysis, to be related to income, educational level, frequency with which other modes were used, years at present address, and family size, but the relationships found by dummy variable regression were not monotonic and were difficult to interpret. The grouping analysis sheds a bit more light on the relationships. In group 4, high preference for pleasant scenery is associated with high income, high levels of education, and frequent use of other modes of travel. In group 1, we find preference for pleasant scenery associated with older respondents, and those who make longer trips to work. In group 5, we find that low preference for pleasant scenery is associated with low levels of education, and high proportions of blue-collar workers. For the sample surveyed, a preference for pleasant scenery is clearly related to social rank, and becomes more important with increasing trip length.

CONCLUSIONS AND EVALUATION

The analysis indicates that reasonably strong relationships do exist between the attitudes of the respondents toward the type of route which they seek when they make a trip, and the characteristics of the respondents, their trips, and the routes to which they have been exposed. The relationships found could not have arisen randomly.

Although it was possible to investigate these relationships in some detail, the results were not always entirely satisfying because some of the relationships found could not be clearly explained on logical grounds. After a very brief recapitulation of the major findings of this section of the study some possible explanations will be offered for the shortcomings of the attempt to specify more effectively the individual attitudes in terms of person and trip characteristics.

The major findings of the preceding analysis may be summarized as follows:

1. People's preferences for various route characteristics do vary, and the variations can be related to the characteristics of the people, their trips, and the routes to which they have been exposed.
2. Responses to attitudinal statements about reasons for route choice do not vary greatly with the type of trip. Differences which do exist seem to be related to the grea importance of direct and quick access to the destination in the trip to work, and the increasing importance of amenities, such as comfort and pleasant scenery, in more leisurely visiting trips.
3. Factor analysis is a useful method for the reduction of a battery of attitudes about route choice to fewer independent and interpretable dimensions.
4. Drivers' attitudes toward which factors are important in the choice of a route for the trip to work appear to be strongly influenced by the length of the trip they are making.
5. Drivers seem to be able to satisfy their preferences for many route characteristics. Drivers who express preferences for many route characteristics actually tend to travel on routes which possess them, whereas drivers who express little preference for such characteristics tend to drive on routes which do not possess them.

There are several possible reasons for the strong relationships found between the attitude variables and some of the independent variables used in the regression analysis. Logical explanations for some of these are impossible or extremely tentative. For example, the family size of the respondents, or the number of drivers in their households, often appeared to exert a stronger influence on their attitudes than age, income, educational level, etc. We might intuitively expect a person's social status or stage in the life cycle to bear stronger relationships to his attitudes than some of the variables which were more important "explainers" of attitudes in the regressions. The probable cause of this result is the fact that the population of respondents is biased toward the upper-income levels and higher educational levels. Certain variables, including family size and number of drivers in the household, vary over as wide a range as one might expect to find in a truly random sample of American citizens; however income, education, and race contain much less variance in this sample than in a typical sample of drivers.

Because regression analysis is essentially a treatment of the covariation among variables, if certain variables have variances which are restricted to an abnormally small range, they will not appear as important as one might intuitively expect, whereas variables which are not so restricted in variance may be overemphasized. This is particularly possible in a small sample where chance covariations between, say, famil size and attitudes are more likely to occur than in larger samples. As was explained earlier, the measures used in the analysis as characteristics of the respondents' route were not adequate to fully specify the nature of those routes.

If the attitudes of individual drivers toward the characteristics of transportation facilities are to be effectively utilized in the evaluations of such facilities in order to make choices between alternatives correspond more effectively to the values of the users, we must first identify the elements of service on which the users place positive value, and the absence of which they perceive as costs. Second, we must learn something of the relative importance of these values, and the variations in the relative importance with variations in the characteristics of the people and in those of the facility. A third step which we may or may not want to take is the translation of these relationships to economic or monetary terms. This research has attempted to demonstrate that the first two steps are feasible, but has not attempted to wrestle with the third—a most difficult problem.

In spite of the limited success in some of the stages of the research, the methods used here have demonstrated that it is feasible to isolate the elements of value and cost as perceived by the driver, to examine interrelationships between these elements, and to relate them to the characteristics of the drivers and the facilities in question. It is hoped that this methodology, and the conclusions of this research will have application and value in the urban transportation planning and evaluation process.

ACKNOWLEDGMENTS

The research reported in this paper was done with the support of the Transportation Center at Northwestern University, through NCHRP Project 8-4. The author is grateful for this support, and for the help and advice of Professor William L. Garrison, Director of the Center; Professor Edwin Thomas, Director of Research; and Mr. Joseph L. Schofer, Co-Principal Investigator for Project 8-4.

REFERENCES

1. Bartlett, M. S. The Statistical Significance of Canonical Correlations. Biometrika, Vol. 32, pp. 29-38, 1941.
2. AASHO Committee on Planning and Design Policies. Information Report on Road-User Benefit Analysis for Highway Improvements. AASHO, Washington, 1960.
3. Casetti, Emilio. Classificatory and Regional Analysis by Discriminant Iterations. Tech. Rept. No. 22, ONR Task Number 389-135, NONR Contract Number 1228(26), Northwestern Univ., Evanston.
4. Claffey, Paul J. Characteristics of Passenger Car Travel on Toll Roads and Comparable Free Roads. HRB Bull. 306, 1961.
5. Cooley, William W., and Lohnes, Paul R. Multivariate Procedures for the Behavioral Sciences. John Wiley and Sons, New York, pp. 151-185, 31-59, 1962.
6. Guilford, J. P. Psychometric Methods. Second Edition, McGraw-Hill Book Company, New York, pp. 395-398, 1954.
7. Guilford, J. P. Fundamental Statistics in Psychology and Education. Third Edition, McGraw-Hill Book Company, New York, p. 436, 1956.
8. Guttman, Louis. The Test-Retest Reliability of Qualitative Data. Psychometrika, Vol. 11, pp. 81-95, June 1946.
9. Haney, Dan G. The Value of Time for Passenger Cars: Further Theory and Small Scale Behavioral Studies. Stanford Research Institute, Menlo Park, Calif., 1964.
10. Harman, Harry H. Modern Factor Analysis. Univ. of Chicago Press, 1960.
11. Hotelling, Harold. Relations Between Two Sets of Variates. Biometrika, Vol. 26, pp. 139-142, 1935.
12. McQuitty, Louis L. Elementary Linkage Analysis for Isolating Orthogonal and Oblique Types and Typal Relevancies. Educational and Pscyhological Measurement, Vol. 17, No. 2, pp. 207-229, Summer, 1957.
13. Michaels, Richard M. Attitudes of Drivers Toward Alternative Highways and Their Relation to Route Choice. Highway Research Record 122, pp. 50-74, 1966.
14. Morgan, James N. A Note on the Interpretation of Multiple Regression Using Dummy Variables. Survey Research Center, Institute for Social Research, Univ. of Michigan, mimeo, April 28, 1964.
15. Siegel, Sidney. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill Book Company, New York, pp. 127-136, 1956.
16. St. Clair, G. P., and Leider, Nathan. Evaluation of the Unit Cost of Time and of Strain and Discomfort of Driving. HRB Spec. Rept. 56, pp. 116-129, 1960.
17. Suits, Daniel. The Use of Dummy Variables in Regression Equations. Jour. Amer. Statistical Assoc. 52, Dec. 1957.
18. Torgerson, W. S. Theory and Method of Scaling. John Wiley and Sons, New York, 1958.
19. Wachs, Martin. Evaluation of Engineering Projects Using Perceptions of and Preferences for Project Characteristics. Unpublished PhD dissertation, Northwestern Univ., Evanston, 1967.