Faculty Working Papers

PERCEIVED ATTRIBUTE IMPORTANCE IN PUBLIC AND PRIVATE TRANSPORTATION

Thomas Golob and Ricardo Dobson,
General Motors Research Laboratories

Jagdish N. Sheth, University of Illinois

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A group of 500 mail panel respondents rated attributes of two generic classes of innovative urban transportation systems on a seven-point importance scale. A factor analysis of the data resulted in seven interpretable factors to describe the variance of the 40 public transportation attributes and five factors to describe the variance of the 34 private transportation attributes. These latent dimensions of importance were shown via discriminant analyses to have relations to the socio-economic characteristics of the panel respondents. Discriminant analysis was also used to reveal perceptual differences between the two system alternatives with respect to 16 common attributes.

INTRODUCTION

The investment in public and private arterial transportation facilities has been estimated to be approximately $250 billion over the ten-year period 1970-1979, [2]. An investment of this order of magnitude provides ample grounds for accelerating research into consumer preference for transportation systems and for increasing the use of this information in urban transport planning and evaluation. This investigation is one of a series from the General Motors Research Laboratories which documents the attitudes of potential consumers toward innovative modes of urban transportation systems, [3], [4], [5].

A study was conducted to estimate the saliencies of various features of private and public modes of automated urban transportation. The concept of automated systems with dedicated guideways, and possibly with central energy source and control facilities, has become increasingly relevant in recent years because of the promise it provides in solving certain urban transportation problems. Perhaps the most useful research in urban transportation analysis is with regard to the attitudes and preferences of consumers of these systems. It is increasingly relevant to understand the psychology of the consumers in view of the fact that demographic factors and cost information alone are often of limited importance in describing and predicting demand in a mass consumption society, [8].

STUDY DESIGN

A study was therefore designed to estimate consumers' saliencies of relevant attributes with regard to the generic classes of public and private modes of transportation on automated guideways.

The sample of respondents came from a mail panel maintained by a well-known market research firm. All respondents resided in the Detroit Standard Metropolitan Statistical Area as defined by the 1970 United States Census. While the panel is derived via a quota sampling procedure, it is balanced to census statistics on total income, age of panel member, and degree of urbanization for the community of the household. For half of the panel households, the male head of the household was designated as the respondent, while the female head of the household was designated as the respondent for the remainder.

The questionnaire used to collect attribute attitudinal data was sent to 700 respondents over five weekdays, and the collection effort was terminated approximately one month later. A total of 568 questionnaires were returned during the collection period. Of that total, 500 respondents answered all 74 attitudinal questions for a return rate of complete questionnaires of 71%.

The questionnaire was divided into two parts. One section investigated public transportation, and the other section investigated private transportation. After a brief verbal tableau, respondents were instructed to rate a set of attributes on a seven-point importance scale; a rating of 1 corresponded to extreme importance, while a 7 corresponded to no importance at all.

The attributes were selected in order to describe specific features of the types of transportation being studied and were generally consistent with previous attitude surveys of public and private transportation system, [4], [10], [11]. Some attributes were identical for the two types of transportation; for example, "short rush-hour travel times" and "arriving when planned".

The major objectives of the study were as follows: (1) Investigate the underlying structure of attribute dimensions with respect to the classes of public and private modes of transportation; (2) Examine socioeconomic-demographic correlates of the multidimensional attitude structure for each class of modes; and finally (3) Examine differences in people's attitudes toward features of public versus private modes of automated urban transportation. The findings of this study were employed in the design of a more detailed case study of the demand for specific automated guideway systems.

FINDINGS AND DISCUSSION

The means and standard deviations of the importance ratings assigned by the 500 respondents to the 40 public and 34 private transportation system attributes are listed in Table 1. The correlations of .68 and 0.85 between the means and standard deviations of public and private transportation system attributes, respectively, indicate a greater consensus among the respondents for more important attributes. Furthermore, the relative importances for public and private transportation systems are different on a number of common attributes.

Attribute Structure of Public Transportation

In order to understand the multidimensionality of preferences toward features of automated public transportation systems, a factor analysis was performed on the 40 attributes correlation matrix. The objective of factor analysis is to derive a set of latent dimensions as functions of the variance-covariance structure among the observed variables in the most parsimonious and interpretable manner possible. In light of no a priori theory about this structure, a principal components analysis and a varimax orthogonal rotation was used, [7], [9].

The results of the factor analysis are summarized in Table 2. A total of seven factors were retained which accounted for 56% of the total variance in the 40 manifest attribute importances. The choice of seven factors was based on the trade-off between parsimonious description and sufficiency of explained variance. The ability to interpret each of the latent factors comprising a solution also played a role in the selection process.

The factor loadings matrix, which relates the seven latent factors to the original attributes through product-moment correlation coefficients, is provided in Table 2. Only factor loadings (correlations) with absolute values greater than or equal to 0.48 are shown; this value was found to be associated with relatively large gaps in the ordered continuum of loadings for each factor. Using Table 2, the interpretations of the factors can then be expressed as follows: factor 1 - level of service (18.7% of the original variance), factor 2 - quality and comfort (10.3%), factor 3 - amenities and options (7.0%), factor 4 - man-machine interface (5.7%), factor 5 - shopping convenience (5.6%), factor 6 - choice of first-class service (4.6%), and factor 7 - duration of service (4.3%).

Investigation of the communalities (i.e., multiple coefficients of determination, R^2) between each attribute and the complete set of seven factors (see Table 2) reveals that a substantial portion of the variance associated with each and every attribute was accounted for, even though four attributes failed to exhibit a factor loading of 0.48 or greater. The highest communality was 0.68 for "short waiting time", while the lowest communality was 0.41 for "temperature control". The mean of these 40 communalities is given by the total percentage of original variance accounted for (0.561); the standard deviation of the communalities was only 0.058, suggesting fairly good homogeneity in the factor structure.

The seven dimensions are fairly easy to interpret and quite meaningful. They represent various aspects of product attributes salient to public transportation. In order to determine demographic correlates of these attribute dimensions, a series of discriminant analyses were performed in which the total sample respondents were

segmented into two or more groups on a specific demographic variable. For example, male and female respondents were discriminated to see if there were any significant differences with respect to the seven dimensions. The significant mean differences among the demographic segments with respect to these seven factors are reported in Table 3.

As can be seen from the table, female respondents are more concerned with man-machine interface (factor 4) and with shopping convenience (factor 5), while males are more concerned with amenities and options (factor 3). Central city residents are more concerned with man-machine interface (factor 4) and with duration of service (factor 7) than the suburbanites. The respondent's age has some very interesting differences with respect to the dimensions of attribute saliencies. The younger respondents (age 34 yrs. or younger) are less interested in level of service (factor 1), in amenities and options (factor 3), in man-machine interface (factor 4), in choice of first class service (factor 6), and more interested in shopping convenience (factor 5) than others. The middle-aged respondents are more interested in level of service (factor 1), and less interested in amenities and options (factor 3), in man-machine interface (factor 4), in shopping convenience (factor 5), and in choice of first-class service (factor 6) than the oldest respondents in the sample. Finally, low income (less than $6000) are more concerned with level of service (factor 1) with man-machine interface (factor 4), with shopping convenience (factor 5), and with duration of service (factor 7) than other respondents.

It should be noted that the differences in the saliency of public transportation attributes with respect to age and income segments are

neither linear nor even monotonic. The linearities of the various factor-demographic relationships were tested through regression and canonical correlation analyses, although no additional insights were achieved over and above the discriminant results.

Attribute Structure of Private Transportation

A factor analysis of the 34 attribute saliency ratings for the private transportation system resulted in five latent dimensions which combined together retained 53 percent of the total variance in the manifest data. The same judgments were utilized for the choice of principal components analysis, selection of factors and their varimax orthogonal rotation.

The factor loadings matrix and attribute communalities are summarized in Table 4; loadings with absolute value greater than or equal to 0.44 are shown. The interpretations of the factors consequently are as follows: factor 1 - personal security/parking convenience (13.4% of the original variance) factor 2 - level of service/ accessibility (13.4%) factor 3 - cost (11.5%), factor 4 - comfort (7.1%), and factor 5 - guideway-vehicle interface (7.1%). Only factors 1 and 4 are directly related to factors determined for public transportation, and even these two factors must be adjusted in meaning between private and public systems alternatives; level of service is expanded in the private transportation situation to include the accessibility dimensions associated with the more ubiquitous destination set characterizing present, modes of private transportation, while comfort assumes a more restricted role in the private situation.

The communalities between the 34 private attributes and the five latent factors varied over a much greater range than did the communalities

between the public attributes and factors. The highest communality here was 0.74 for "low operating cost" and the lowest communality was 0.32 for "not having to drive (your own vehicle on the guideway)". The standard deviation of these communalities for the private attributes was 0.102, as opposed to 0.058 for the public attribute communalities. Since the inclusion of one or two more factors in the solution failed to substantially increase the majority of the low communalities, it was concluded that underlying perceptual factors controlling attribute services toward the automated private transportation systems are less easily identified than those controlling saliences toward automated public transportation systems. This contrast may be due to the relative unfamiliarity respondents have with possible future changes to the existing automobile/roadway systems and, consequently, they have diverse perceptions of attributes concerning automation.

Again, in order to examine demographic differences in the factor structure of attribute saliencies, a series of discriminant analyses were performed among segments of respondents defined a priori on each of the four demographic variables. The statistically significant differences are summarized in Table 5.

Female respondents are more concerned with personal security/parking convenience (factor 1) and with comfort (factor 4). The central city residents are more concerned with comfort (factor 4) than the suburbanites. This is surprising and contrary to the expectations of the utility theory.

With respect to the age of the respondent, the oldest respondents are more concerned with personal security/parking convenience (factor 1) and less concerned with level of service accessibility (factor 2) and

with costs (factor 3). The results are surprising with respect to the accessibility factor. Finally, the higher income respondents consider level of service/accessibility as being more important than the lower income respondents. However, with respect to the cost factor there is a non-monotonic relationship: both the highest income and the lowest income respondents expressed less concern than the middle-income respondents. This non-monotonic relationship is congruent with several recent studies in consumer grocery products. It is interpreted here in the following way: persons in middle-income families are directly faced with decisions involving the financing of an additional automobile and are more sensitive to the costs involved; persons in lower or upper-income families are more insensitive to these issues due to the relative inapplicability the additional auto decision.

Comparison of Public and Private Transportation

The nature of the two transportation alternatives in the current investigation required some attributes to be rated in only one part of the questionnaire. For example, "not having to transfer" was used only in the public transportation section, while "short park times" was used solely in the private transportation section. On the other hand, other attributes, such as "short rush hour travel times", could be conveniently asked in both sections. The list of 16 common attributes is provided as part of Table 6.

In order to ascertain the influence of individual common attributes, a discriminant analysis was performed on the common attributes for the two transportation alternatives. The ratings of each respondent were classified into two groups, depending on which alternative

was evaluated. Moderate improvements in the correct classification of the ratings occurred for the addition of the first four variables, but after the fourth variable was added the percentage of correctly classified observations did not improve. However, the discriminant function was statistically significant with both four ($F = 20.04$, $df = 4,995$, $p < .01$) and sixteen ($F = 6.55$, $df = 16,983$, $.05\ p < .01$) variables. The classification table for the sixteen variable discrimination indicated 63.4% correct classification.

Table 6 lists the scaled discriminant weights for all sixteen common attributes, [12]. In general, those attributes with negative discriminant weights are more important for public transportation, while those with positive weights are more important for private transportation. For example, "stations (entrances/exits) near home" and "helpful employees" are perceived to be more important for public transportation. See Table 1 for further examples. Station location seems to be a critical variable in the evaluation of public transportation for this sample of respondents. The respondents want their system access points close to home, work, and shopping when they evaluate public transportation. The attributes are listed in the order of the absolute value of their scaled discriminant weight.

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TABLE 1

PRIVATE			ATTRIBUTES	PRIVATE		
MEAN	S.D.	RANK*		MEAN	S.D.	RANK*
2.2	1.6	26	24 hour operation	3.0	2.0	26
2.1	1.3	23	Short non-rush hour travel time	2.6	1.6	24
2.0	1.3	19	Entrances/exits (stations) near home	2.0	1.4	10
2.2	1.3	25	Helpful employees	2.2	1.4	14
1.9	1.2	14	Short rush hour travel time	2.3	1.5	15
2.1	1.5	22	Pollution-free vehicle	2.4	1.7	19
1.6	0.9	5	Arriving when planned	1.6	1.1	3
1.7	1.0	11	Ease of finding where to go	1.9	1.3	8
2.4	1.4	28	Comfortable, cushioned seats	2.8	1.6	25
2.0	1.4	18	Entrances/exits (stations) close to work	2.1	1.6	12
5.1	1.8	34	Futuristic vehicle	5.4	1.6	38
1.3	0.8	1	Safe from vehicle accidents	1.4	1.1	1
1.7	1.1	10	Same day - day travel time	1.9	1.4	7
2.3	1.5	27	Entrances/exits (stations) near shopping	2.4	1.7	20
2.2	1.3	24	Smooth, quiet ride	2.4	1.5	18
2.1	1.5	21	Able to get to many places	2.4	1.8	17
			Low fares	2.2	1.4	13
			Comfortable seats, waiting	3.8	1.8	31
			Room for packages	3.5	1.8	27
			Protection from weather, waiting	2.0	1.4	9
			Not crowded, waiting	2.6	1.6	23
			Refreshments & newspapers	4.8	1.9	37
			Temperature control	3.7	1.9	29
			Able to read	3.8	2.0	32
			Reserve seat in advance	4.4	2.0	36
			Not having to transfer	2.3	1.5	16
			Clean vehicle	1.8	1.2	4
			Having a driver	3.5	2.2	28
			Able to get seat all times	2.4	1.6	21
			Room for strollers	4.4	2.1	35
			Sit & talk with others	3.8	1.9	33
			No stair climbing	3.8	2.1	30
			Safe from harm by others	1.4	1.1	2
			Short waiting time	1.8	1.3	6
			Direct route	2.1	1.4	11
			Choose first class	4.4	2.1	34
			Short walking time	2.4	1.5	22
			Having private section	5.9	1.6	40
			On time, all weather service	1.8	1.3	5
			Listen to radio on vehicle	5.6	1.7	39
2.5	1.6	29	Space between vehicles			
2.5	1.6	30	Able to use if full			
3.7	1.9	32	Reserve space in advance			

TABLE 1 (cont.)

PRIVATE			ATTRIBUTES	PRIVATE		
MEAN	S.D.	RANK*		MEAN	S.D.	RANK*
4.2	2.0	33	Able to use if vehicle poor			
1.5	0.9	3	Low repair cost			
2.0	1.4	17	Able to change			
1.3	0.7	2	Not worrying: vehicle stolen...			
1.6	1.0	6	Use in all weather			
2.1	1.2	20	Short times to park			
1.9	1.2	15	Short park times			
1.9	1.2	16	Short time walking from park			
1.6	1.0	8	Low parking cost			
1.6	1.1	9	Long lasting vehicle			
2.8	1.9	31	Not having to drive			
1.8	1.1	12	Not having delays			
1.8	1.3	13	Low toll charge			
1.6	1.0	4	Low operating cost			
1.6	1.1	7	Low purchase cost			

*RANK OF 1 ASSIGNED TO SMALLEST MEAN VALUE
(GREATEST MEAN IMPORTANCE RATING)

TABLE 2

ATTRIBUTES	FACTOR 1	2	3	4	5	6	7	COMMUN-ALITIES
SAME DAY - DAY TRAVEL TIME	.65							.61
24 HOUR SERVICE							.66	.61
LOW FARES								.51
COMFORTABLE SEATS, WAITING		.57						.59
ROOM FOR PACKAGES					.63			.62
PROTECTION FROM WEATHER, WAITING		.51						.56
NOT CROWDED, WAITING		.60						.55
REFRESHMENTS AND NEWSPAPERS			.63					.51
EASE OF FINDING WHERE TO GO	.49							.54
FUTURISTIC VEHICLE			.63					.48
TEMPERATURE CONTROL								.41
HELPFUL EMPLOYEES		.52						.55
ARRIVING WHEN PLANNED	.69							.63
STATIONS NEAR SHOPPING					.52			.56
STATIONS NEAR HOME	.65							.59
ABLE TO READ			.64					.64
RESERVE SEAT IN ADVANCE								.49
NOT HAVING TO TRANSFER								.47
CLEAN VEHICLE	.50	.48						.55
SHORT NON-RUSH HOUR TRAVEL TIMES	.62							.51
SHORT RUSH HOUR TRAVEL TIMES	.66							.58
SMOOTH, QUIET RIDE		.54						.58
HAVING A DRIVER				.56				.47
ABLE TO GET SEATS ALL TIMES		.56						.56
ROOM FOR STROLLERS					.54			.49
SIT AND TALK WITH OTHERS					.50			.57
POLLUTION-FREE VEHICLE				.59				.56
NO STAIR CLIMBING				.61				.58
SAFE FROM HARM BY OTHERS	.59							.59
SHORT WAITING TIME	.74							.68
DIRECT ROUTE	.63							.57
ABLE TO GET TO MANY PLACES	.50							.44
CHOOSE FIRST CLASS						.68		.60
SHORT WALKING TIME	.63							.58
HAVING PRIVATE SECTION						.68		.66
ON TIME, ALL WEATHER SERVICE	.66							.52
STATIONS CLOSE TO WORK	.68							.52
COMFORTABLE, CUSHIONED SEATS		.65						.55
LISTEN TO RADIO ON VEHICLE			.67					.59
SAFE FROM ACCIDENTS	.60							.59
PROPORTION OF VARIANCE	.187	.103	.070	.057	.056	.046	.043	0.56

TABLE 3

DEMOGRAPHIC GROUP	GROUP MEAN ON FACTOR*						
	1	2	3	4	5	6	7
Sex:							
(1) Male			-.128	.175	.187		
(2) Female			+.110	-.150	-.160		
Income:							
(1) Less than $6,000	+.564			-.474	-.316		-.102
(2) $6,000 - $10,000	-.020			-.123	+.024		-.411
(3) $10,000 - $15,000	-.011			-.029	-.154		-.002
(4) More than $15,000	-.097			+.187	+.205		+.226
Age:							
(1) Less than 35 yrs.	+.091		-.269	+.252	-.337	+.163	-.142
(2) 35 - 54 yrs.	-.168		+.047	-.032	+.181	-.067	+.127
(3) 55 yrs. or older	+.142		+.379	-.376	+.258	-.161	+.020
Residential location:							
(1) Central City				-.238			-.169
(2) Suburbs				+.108			+.077

*lower values on a factor indicate greater expressed importance

TABLE 4

ATTRIBUTES	FACTOR 1	2	3	4	5	COMMUN-ALITIES
Short rush hour travel times		.66			.44	.56
Arriving when planned		.44				.48
Comfortable seating				.71		.61
Space between vehicles						.41
Able to use if full		.45				.39
Safe from vehicle accidents	.67					.59
Helpful employees	.49					.49
Reserve space in advance					.62	.46
Able to use if vehicle poor					.65	.46
Futuristic vehicle					.64	.46
Low repair cost			.62			.61
Able to change						.41
Not worrying: vehicle stolen...	.59		.46			.64
Get to many places		.47				.40
Use in all weather	.53	.48				.59
Short times to park	.72					.70
Short park times	.71					.68
Short time walking from park	.50					.41
Low parking cost	.52		.53			.64
Pollution-free vehicle				.56		.45
Entrances/exits near home		.46				.53
Long lasting vehicle			.68			.51
Ease of finding where to go	.44					.43
Not having to drive						.31
Smooth, quiet ride				.48		.60
Entrances/exits close to work		.55				.52
Entrances/exits near shopping						.42
24 hour operation		.58				.53
Short non-rush hour travel times		.68				.55
Not having delays		.59				.54
Low toll charge			.49			.42
Low operating cost			.80			.73
Same day - day travel time		.51	.51			.56
Low purchase cost			.77			.67
PROPORTION OF VARIANCE	.136	.134	.115	.071	.071	0.52

TABLE 5

DEMOGRAPHIC GROUP	GROUP MEAN ON FACTOR*				
	1	2	3	4	5
Sex:					
(1) Male	+.216			+.159	
(2) Female	-.186			-.136	
Income:					
(1) Less than $6,000		+.799	+.234		
(2) $6,000 - $10,000		+.188	-.250		
(3) $10,000 - $15,000		-.040	-.105		
(4) More than $15,000		-.220	+.176		
Age:					
(1) Less than 35 yrs.	+.274	-.041	-.198		
(2) 35 - 54 yrs.	-.123	-.178	+.106		
(3) 55 yrs. or older	-.253	+.387	+.162		
Residential Location:					
(1) Central City				-.171	
(2) Suburbs				+.078	

*lower values indicate greater expressed importance

TABLE 6

Attribute	Scaled Discriminant Weight
24 Hour Service	.66
Short rush hour travel times	.41
Helpful Employees	-.41
Short non-rush hour travel times	.38
Station near home	-.32
Arriving when planned	-.32
Pollution-free vehicle	.19
Comfortable, cushioned seating	.18
Ease of finding where to go	.18
Stations close to work	-.18
Safe from accidents	.15
Same day-day travel times	.13
Futuristic vehicle	.12
Smooth quiet ride	-.12
Stations near shopping	-.11
Able to get to many places	.00

CLASSIFICATION RESULTS Predicted Actual	Private	Public
Private	.70	.30
Public	.43	.57