Travel Mode Choice Behavior and Physical Barrier Constraints Among the Elderly and Handicapped: An Examination of Travel Mode Preferences

BRUNO P. PAROLIN

The objective of this research is to obtain a clearer understanding of the relationships between physical barrier disability characteristics and the processes of travel mode choice. Specifically, the attempt is to understand the second stage of the travel decision-making process—the formation of travel mode preferences among the elderly and handicapped. To this end, an integrated methodology using personal construct theory, multidimensional unfolding, and cluster analysis was developed and tested for a sample population of the elderly and handicapped in Columbus, Ohio. Cognitive dimensions were latently derived for five internally homogeneous groups. Latently derived dimensions for the five groups highlighted preference sensitivities toward accessibility, level of service, cost, and travel burden concerns in the process of travel mode preference formation. These sensitivities were found to be related to varying levels of personal physical disabilities. In essence, it is the varying levels of physical disabilities that define the dimensions of travel mode preference used in the second stage of the travel mode choice decision-making process. These findings are discussed in terms of their policy implications.

In the last decade, one important focus of transportation research has been the "paradigm of travel behavior." The structure of travel mode choice behavior considered by this paradigm is expressed in various models of perception, preference, and choice (*1–4*). Numerous applications of the paradigm in transportation research contexts have largely been confined to the urban mobile population. Transportation disadvantaged, or mobility restricted, segments of the population, such as the elderly and handicapped, have received only limited attention in terms of the travel mode choice decision-making paradigm. Recognition of the importance of this paradigm is evident in the literature on the elderly and handicapped (*5, 6*).

The need for more extensive research using the travel mode choice behavior paradigm among the elderly and handicapped is pressing. This stems from the legislative guidelines and transportation policies that have been introduced in the United States, in the last decade, to improve the mobility and accessibility of the elderly and handicapped in urban areas. Programs and policies have generally been implemented without prior knowledge of the structural relationships between individual physical disability characteristics and the processes of travel mode choice. To date, research that attempts to understand the elderly and handicapped's formation of perception of travel modes—how perceptions combine to determine travel mode preferences and how, conditioned by individual and situational characteristics, final travel choices are made—is very limited (*7, 8*).

School of Geography, University of New South Wales, P.O. Box 1, Kensington, N.S.W., Australia 2033.

Research that uses an attitudinal approach toward the travel mode choice processes of the elderly and handicapped is reported in this paper. Fundamental to this approach is a focus on the second stage of the travel decision-making process, that is, how preferences for travel mode alternatives considered by the elderly and handicapped, with varying levels of personal physical disabilities, are formed for purposes of determining final mode choice.

The purpose of these objectives is to better understand the relationships between varying levels of personal physical disabilities among the elderly and handicapped and the attributes that compose broader dimensions of travel mode preference. Knowledge of these relationships should provide useful information to policy makers and transit managers alike. This knowledge should enable decision makers to identify the supply components of a responsive and equitable transportation system for the elderly and handicapped.

LITERATURE

A substantial body of literature exists on the transportation problems of the elderly and physically handicapped. The focus of this section is on those few examples of research that stress relationships between personal physical disabilities, preferences for travel mode alternatives, and preferred travel mode attributes.

An attitudinal assessment of preferences among the elderly and handicapped is seen in the research of Paaswell and Recker (*9*). The findings of interest to this research relate to the results of using multivariate scaling methods in attitudes toward more general characteristics of travel modes. Several modal characteristics were rated as very important by the sample. In order of importance they were vehicle safety; vehicle riding time; vehicle comfort; and familiarity with routes, fares, and schedules. These findings emphasize the importance of travel burden (ease of travel) factors when using travel modes.

Other research by Gauthier (*10*) also identified those travel mode attributes that contribute most to the elderly and handicapped's perceptual evaluation of a transportation system in Columbus, Ohio. Perceptual evaluation was determined to consist of five dimensions, identified as difficulty of travel, convenience, flexibility, safety, and comfort. The preferred attributes on the difficulty of travel dimension were assistance to the vehicle and assistance to a service pick-up point. The preferred attributes of convenience were identified with the type of vehicle being used. In terms of the flexibility dimension, the sample displayed preferences for control over route scheduling. Preferred attributes of safety and comfort dimensions were limited seating capacity, ability to restrict number and types of passengers, and the provision of grabrails, seatbelts, and wheelchair locks.

These preferred attributes demonstrate the elderly and handicapped's concern with accessibility in the travel environment and a minimal effort to use any travel mode. More important, the study found that travel mode preference is for a dial-a-ride service known as Project Mainstream Van Service. Project Mainstream is a preferred travel mode alternative because it is perceived to meet the elderly and handicapped's criteria of accessibility and minimal effort in the travel environment. The findings of Paaswell and Recker suggested the introduction of a dial-a-ride service in Buffalo, New York (*8*).

A consideration of the effects of physical disabilities on travel mode attribute preferences is represented by several researchers (*11–13*). In the former, three market segments of the elderly and handicapped are defined according to functional disability. It was found that travel and mobility patterns varied by market segment according to the severity of functional disability. More important, it was found that preferences for travel mode improvements also varied according to identified market segments. The tendency of preference for both segregated (e.g., special van service) and integrated (e.g., public bus) modes was seen as a result of the diminishing desire to use the private automobile as the severity of functional disability became more extreme.

The research of Dallmeyer and Surti (*12*) analyzed six classifications, or market segments, based on severity of physical disability. These ranged from "need a person's help to get around" to "no limitations." Several findings are of interest. First, those segments with more severe physical disabilities relied almost exclusively on special van services or other people for travel. Those segments characterized by fewer and less severe physical disabilities relied more on less expensive modes such as the bus or family and friends. Second, the preferred attributes toward transportation improvements varied by market segment. For the two wheelchair user segments, preference was displayed for more accessible buses, and installing wheelchair lifts and tie-downs on buses. Finally, the less constrained and more ambulatory segments displayed preference for buses with lower stairs, wider doors, larger route signs, driver courtesy, and no long waits for transfer between points.

The research of Miller (*13*) focused on those attributes of transportation systems that are of most importance to segments of the elderly and handicapped. Market segments of the elderly and handicapped are defined by the types of physical disabilities they experience using the statistical technique of cluster analysis. Seven distinct market segments emerge, ranging from most disabled to least disabled. It was found that attribute importance, as measured along an interval scale, varied according to the type of physical disability possessed and, thus, by market segment. Furthermore, it was found that more disabled segments attach greater importance to travel mode attributes than do less disabled groups. Finally, it was found that more of the sample population were concerned with accessibility and travel burden attributes—a lot of stairs and standing while waiting for a travel mode.

More recent research has investigated the relationships between physical disabilities among the elderly and handicapped and the dimensions of travel mode attribute perceptions (*14*). Although dealing only with the first stage of the travel mode choice process, several findings are of interest. First, attributes used in the process of evaluating travel modes were examined and cognitive dimensions of travel mode attribute perceptions were latently derived for five internally homogeneous groups of the elderly and handicapped sample population. Groups were statistically determined from data on types of personal physical disabilities.

Second, latently derived dimensions for the five groups highlighted differences in perceptual sensitivities. Groups with minor or no physical disabilities possessed dimensional structures concerned with effort and mobility in the travel environment. The travel mode that most satisfied their perceptual criteria was the fixed-route bus service. The dimensional structure of the more physically disabled groups indicated a concern with modal accessibility. The automobile-passenger travel mode satisfied the perceptual criteria of the more physically disabled groups.

Finally, a statistical analysis of group evaluations of elicited attributes indicated the existence of significant group differences in the way that elicited travel mode attributes are rated. This finding suggested that it is the varying levels of physical disabilities that define the dimensions of travel mode attribute perceptions used in the first stage of the travel mode choice process. How travel mode attribute perceptions combine to determine preferences among the elderly and handicapped—with varying levels of personal physical disabilities—is the next least understood aspect of the travel mode choice process.

In reviewing this literature, it is evident that certain relationships exist between physical disability, preferred attributes of a transportation system, and preference for travel mode alternatives. Preference for accessibility attributes might indicate that they are the more salient attributes in the travel mode choice process. In turn, preference for certain types of travel modes (e.g., dial-a-ride van services) might indicate that they are the only modes that satisfy attribute screening criteria in the process of modal evaluation. However, this knowledge is not known from the literature because the travel environment of the elderly and handicapped has generally not been viewed as a travel mode choice process (i.e., how perceptions of travel modes and travel attributes are combined to determine preferences for alternative travel modes). Travel mode preferences and the formation of cognitive preference dimensions among the elderly and handicapped is the second stage of the travel choice process that this research seeks to understand.

An examination of the aforementioned problems was conducted through the use of an interview survey in Columbus, Ohio.

RESEARCH METHODOLOGY

A research methodology is outlined that operationalizes the major tasks of the research. In the winter of 1982, an extensive interview survey was undertaken of 81 elderly and handicapped residents in Columbus, Ohio. Finding the residential location of the elderly and handicapped did not prove difficult. The local transit authority maintains an updated mailing list of subscribers to its Project Mainstream Van Service—a special wheelchair-lift-equipped van service sponsored by the Central Ohio Transit Authority (COTA). Most addresses on the list are simply those of nursing homes, convalescent centers, and retirement villages where individuals reside—some who subscribe to the service and some who do not—who possess the full range of personal physical disabilities.

The interview survey was composed of two portions: (a) a collection of socioeconomic and travel-related characteristics (travel mode preference rank orders) and (b) a determination of individual attributes and attribute evaluation through the construction of repertory grids (*15*). Repertory girds are designed to provide data describing the nature and organization of each individual's subjective attributes of importance via the triad sort method. Several procedures are involved.

In the first procedure, interview respondents are presented with three cards containing the names of three travel modes (i.e., a triad). The respondent is asked to indicate an important way in which two modes are similar and different from the third (i.e., a triad sort). A one-word response was elicited to represent the individual's perceived attribute in the discrimination process (i.e., a personal construct). Each respondent's elicited response is recorded and another triad presented. Triad sorts of different modal combinations are presented until all modal attributes are exhausted or until no additional constructs can be elicited. Travel modes included in the study were the automobile passenger, automobile driver, taxi (personal payment), taxi (social service agency), COTA (regularly scheduled bus), Project Mainstream Van Service, and Magic Carpet Service—a privately operated lift-equipped van service.

The second task sought an evaluation of travel modes on the constructs through a scoring procedure. Each respondent was asked to indicate what level of that construct was possessed by each of the travel modes. A seven-point Likert rating scale was adopted, in which a value of one represented a low perceived construct level and a value of seven represented a high perceived construct level. The first and second procedures produce a matrix for each individual. Each matrix represents the individual's personal attributes used as a criterion in distinguishing between travel mode alternatives. Each travel mode is positioned along the respective single scales.

Before the preference dimensions are derived, the personal physical disabilities among the interview sample are used as a basis for market segmentation. Ten types of personal physical disabilities are used to determine internally homogeneous groups (Table 1). Each group member possesses similar physical disabilities. Individual responses on the types of physical disabilities possessed formed input into a cluster analysis. Ward's HGROUP clustering routine was used in this research (*16*). The broader cognitive preference dimensions are therefore latently derived for each internally homogeneous group.

TABLE 1 PERSONAL PHYSICAL DISABILITIES OF THE INTERVIEW SAMPLE

Physical Disability	Percentage
No serious restrictions affecting use of the transportation system	40.7
Need some special aid such as wheelchair	37.0
No serious problems in standing or walking	29.6
Difficulty in standing	24.6
Difficulty in walking to curb or bus stop	20.9
Severe difficulty in climbing stairs (need assistance)	18.5
Minor difficulty in climbing stairs	17.2
Serious visual impairment	0.0
Must stay in bed all or most of the time	0.0
Must stay in house all or most of the time	0.0

The rationale for establishing homogeneous groups among the interview sample stems from the reviewed literature. Preferred travel mode attributes and preferences for travel mode alternatives differed according to groups who share similar physical disabilities. Generally, the preferred travel modes and attributes are those that overcome physical disability in travel and enhance accessibility and mobility. These findings suggest that the second stage of the travel mode choice process—the formation of preferences for travel mode alternatives—may differ for each identified homogeneous group. An examination of group differences on travel mode preferences and on derived cognitive preference dimensions will further expand knowledge of the relationships between physical disability and the travel-mode choice process.

Interview respondents also provided information on travel mode preference rankings. Each individual rank ordered the seven travel modes on a scale of one to seven with one representing least preferred and seven representing most preferred. The travel mode preference rank orders for each identified group form matrices with n (number of individuals) rows and m (number of travel modes) columns.

The travel mode preference rank order matrix for each identified group was subjected to a multidimensional unfolding analysis (MDU). MDU is used to identify a representative set of travel mode preference dimensions for each group. The MDU model is conceptually similar to the more commonly used multidimensional scaling model (*17*). The object of the MDU model is to find psychological spaces used by individuals in preference choices. Output consists of a stimulus configuration in which both travel modes and subjects are mapped in a multidimensional space. The derived dimensions become the key to assessing relationships between physical disability and the second stage of the travel-mode choice process.

In this research, the interpretation of MDU preference dimensions for each identified group, as supplied by ALSCAL-4, is attempted by a complementary procedure that uses the original repertory grid information (*18*). Unidimensional scale values, based on the Law of Comparative Judgment, are created from original attribute ratings on the repertory grid matrices (*19*). Each attribute construct is treated as a unidimensional solution and each travel mode is positioned along the respective single dimension. Travel mode positions on each unidimensional scale are correlated with travel mode positions on the MDU stimulus configurations. Generally, the higher the correlation between modes on the stimulus configuration and

unidimensional scales, the greater the cognitive salience of that attribute on the preference dimension. This method enables a clearer and more concise interpretation of the MDU cognitive preference dimensions.

RESEARCH RESULTS

In Table 1, the data indicate that the interview sample faces multiple physical disabilities that limit use of public and private travel mode alternatives. A large percentage (30.7 percent) of the sample needs to use a wheelchair. Those less disabled (not confined to a wheelchair), who are able to carry out some functions, still have difficulties in walking and standing. A small percentage (7.4 percent) is visually impaired; when using public transportation this group has problems with being in a crowd. Note that from the first and third categories, an even larger percentage of the sample (17.3 percent) has no restrictions affecting use of the transportation system and no problems in standing or walking. These individuals possess the physical capability to travel, but they do not travel frequently because of age and driver's license constraints. These individuals can be expected to possess different travel mode preference profiles because of the absence of personal physical disabilities.

A total of 39 constructs were elicited from the interview sample using the triad sort method. The 14 most frequently elicited constructs are given in Table 2. Those constructs elicited only once or twice were not included for analysis. In terms of rank, the cost of travel construct was most frequently elicited. This is clearly indicative of the importance attached to cost by a predominantly low-income sample. For this reason the cost of travel becomes an important criterion in distinguishing between travel mode alternatives.

TABLE 2 FOURTEEN MOST FREQUENTLY ELICITED CONSTRUCTS

Construct Label	Frequency of Elicitation
Cost of travel	45
Convenience	30
Friendly and courteous drivers	26
Dependability	25
Assistance on and off the vehicle	23
Flexibility	22
Comfort	16
Suitability of travel mode to needs	15
Independence	14
Frequency of service	13
Ready availability	10
Personal nature of travel mode	7
Sensitivity and understanding of mobility needs	6
Privacy	5

The elicitation of constructs of convenience, friendly and courteous drivers, dependability, and assistance are strongly associated with concerns for accessibility to travel modes and minimal effort in travel. The diverse physical disabilities of the interview sample demand the ability to move from home residence to a travel mode with a minimal effort. Without easy access to a travel mode and some form of assistance, the possibilities for satisfying travel needs and travel demands are limited.

These attribute constructs are therefore important criteria perceived by the interview sample in the first stage of the travel decision-making process. As such, the accessibility and travel burden concerns provide transit managers and transport planners alike with criteria to evaluate the performance of travel mode alternatives available to the elderly and handicapped.

Of interest is the elicitation of the independence construct. It is a clear expression of the notion of personal freedom and mobility. In addition, the independence construct would appear to express the cognitive desire to be like a mobile population (i.e., have access to a car and perform desired activities). The independence construct was most often elicited from wheelchair–bound individuals who associated the automobile-passenger travel mode most highly with personal freedom. The findings of Paaswell and Recker, and Recker and Stevens, also confirm the desire of the mobility limited to be more mobile and to have access to a car and freedom of travel (*9, 20*). Clearly, the independence construct of travel is an additional criterion for planners and others when deciding on the supply and quality of travel services to the elderly and handicapped.

It is argued that differences in cognitive preference dimensions are likely to exist between identified groups who possess diverse travel needs and travel requirements. Ward's HGROUP clustering algorithm was adopted to determine groups with internally homogeneous physical disabilities. Identified in Table 3 are the selected characteristics of the five groups, which are defined as follows:

- Group 1—severe physical disabilities,
- Group 2—wheelchair users,
- Group 3—minor physical disabilities,
- Group 4—visually impaired, and
- Group 5—no serious physical disabilities.

The situational characteristics reveal respective group members to be predominantly female, older, not likely to be employed, and residing in nursing homes or retirement centers. Trip frequency and trip purpose statistics indicate that group members, and indeed the sample population, travel infrequently. The least disabled members of Groups 3 and 4 travel more frequently for more purposes. Medical trips do have importance to the sample, indicating the status of health among the predominantly older sample and the physical disabilities that require specialized medical attention. The shopping and personal pleasure trips are the most popular trips. In general, most group members simply make one or two trips per week to purchase food, visit a doctor, or attend senior citizen functions.

In terms of travel mode preference and use, each group displays orientations to particular travel modes. The travel characteristics of Group 1 indicate that it is automobile-passenger-mode biased. Travel mode use is clearly toward the more private modes. An interesting aspect to this group is its strong preference for Project Mainstream Van Service, followed by automobile-passenger service, with which assistance on and off the vehicle, convenience, comfort, and more personalized service attributes are found. Group 2 members are also automobile-passenger-mode oriented in preference and use. Project Mainstream Van Service, which was primarily implemented for wheelchair users, is neither frequently used nor highly preferred.

TABLE 3 CHARACTERISTICS OF GROUPS

	Group (%)				
	1 (*N*=14)	2 (*N*=24)	3 (*N*=7)	4 (*N*=15)	5 (*N*=21)
Age					
16–29	0	29	0	13	0
30–44	0	12	0	0	0
45–49	16	8	0	6	0
60 or older	84	45	100	80	100
Sex					
Male	35	33	57	26	28
Female	64	66	42	73	71
Dwelling					
House	0	0	28	6	14
Apartment	7	29	0	20	9
Nursing home	71	54	14	53	23
Retirement center	21	4	57	13	52
Employment					
Employed full-time	0	4	0	6	0
Unemployed	23	8	0	6	5
Retired	77	50	100	86	95
Travel Modes Frequently Used					
Automobile-passenger	85	66	57	60	71
Automobile-driver	0	25	42	0	33
Taxi (personal payment)	0	1	28	53	28
Taxi (social service)	0	1	0	0	0
COTA regular bus	35	2	57	60	76
Project Mainstream	0	30	0	100	0
Magic Carpet Service	28	25	0	6	0
Trips per Week on Most Frequently Used Mode					
1	76	45	28	40	47
2–3	15	18	14	20	21
4–5	0	18	28	26	5
6–7	7	9	14	0	15
8–9	0	4	14	6	5
10 or more	0	4	0	6	5
Trip Types					
Work	7	12	14	6	9
Education	0	20	0	6	9
Medical	42	41	42	66	38
Shopping	71	75	85	80	90
Personal business	28	37	85	66	38
Personal pleasure	78	62	85	80	66

The minor disabilities segment (Group 3) is oriented toward the regular bus and automobile-passenger modes in terms of preference and use. Note that private automobile use is highest for this group and that members tend to travel more frequently than other groups. Because of minor physical disabilities, this group is more mobile and oriented to modes with curb-to-curb service, convenience, level of service, and privacy attributes. The visually impaired members of Group 4 travel most frequently on Project Mainstream Van Service. Regular bus and automobile-passenger modes are equally used and taxi service is used by more than half (53 percent) of the members. Group 4 members appear to be oriented toward travel modes that offer high levels of assistance, comfort, and convenience. The most preferred travel mode for the group is the automobile-passenger mode followed by regular bus service. The concern with attributes of access and reduced travel burden appears important.

The least physically disabled group (Group 5) is composed of members who have no serious physical disabilities affecting use of travel modes. The frequently used modes are bus and automobile-passenger, with the most popular being the bus (76 percent). One reason for bus popularity is that over 61 percent of the group resides less than one block from a bus stop. Group 5 members can be characterized as an elderly mobile population. They appear to be a well-developed group of COTA bus patrons where convenience, flexibility, and dependability service attributes are found. Travel mode preference is equally shared by COTA regular bus service and the private automobile. The mean rankings of the travel mode preferences for the five groups are given in Table 4.

The identified groups represent five diverse market segments that possess distinctive physical disabilities and different travel needs and display differences in preferences for travel modes. It is argued that the diversity of disability and mobility among the identified groups would also be associated with distinctive dimensions of travel mode preference. To this end, the MDU analysis of each group's preference matrix provides the cognitive dimensions for each group. Correlations between the MDU stimulus configurations and unidimensional scale values are used for the interpretation of dimensions.

TABLE 4 TRAVEL MODEL PREFERENCES IN MEAN RANKINGS

	Group (%)				
	1 (*N*=14)	2 (*N*=24)	3 (*N*=7)	4 (*N*=15)	5 (*N*=21)
Automobile-passenger	4.6	5.5	5.2	6.0	4.9
Automobile-driver	3.2	4.7	4.8	4.0	5.8
Taxi (personal payment)	4.0	3.1	5.2	4.2	4.7
Taxi (social service)	3.6	2.8	2.8	3.4	2.4
COTA regular bus	3.1	2.4	6.0	5.0	5.5
Project Mainstream	5.0	4.6	2.4	2.8	2.3
Magic Carpet Service	4.2	4.6	1.2	2.4	2.2

Group 1

The preference structure of the severely disabled group is represented by three dimensions of travel mode preference (Table 5):

- Dimension 1—accessibility,
- Dimension 2—travel burden, and
- Dimension 3—personal assistance.

Dimension 1 is highly correlated with the flexibility, convenience, and dependability attributes. This dimension provides a scale for a factor termed accessibility. Preferred travel modes have been ranked in terms of the accessibility they provide—the opportunity to go where and when needed with a dependable travel mode. Dimension 2 is a complex dimension termed travel burden. It correlates most highly with the attributes of independence, availability, comfort, and personal service. It is a dimension that highlights a preference for travel modes offering minimal effort, performance, and personal freedom in the travel environment. Dimension 3 highlights a preference for travel modes providing assistance on and off the vehicle. The concern with assistance appears to represent concern with ease of access to travel modes in order to overcome severe personal physical disabilities.

TABLE 5 GROUP 1: CORRELATIONS BETWEEN ATTRIBUTES AND MDU PREFERENCE DIMENSIONS

	Dimension		
	1	2	3
Independence	0.19	0.89	0.42
	0.33	0.00	0.16
Convenience	0.79	0.56	0.10
	0.01	0.09	0.40
Personal attention	0.33	0.71	0.65
	0.23	0.03	0.05
Flexibility	0.89	0.23	0.01
	0.00	0.30	0.49
Comfort	0.12	0.69	0.71
	0.39	0.04	0.03
Dependability	0.62	0.41	0.13
	0.06	0.17	0.38
Availability	0.41	–0.84	–0.02
	0.17	0.00	0.48
Privacy	0.28	0.59	0.50
	0.27	0.08	0.12
Cost of travel	–0.12	0.03	0.02
	0.39	0.46	0.47
Assistance	–0.17	0.59	0.79
	0.35	0.07	0.01
Suitability	–0.05	0.42	0.73
	0.45	0.16	0.31
Frequency of service	0.45	0.35	0.40
	0.12	0.21	0.18
Sensitivity and understanding	0.44	0.66	0.71
	0.15	0.05	0.03
Friendly and courteous drivers	0.48	0.53	0.65
	0.13	0.10	0.05

NOTE: The second number in each cell is the probability of the correlation coefficient's being equal to zero.

Group 2

The best overall fit for the wheelchair group is a four-dimensional preference solution (Table 6):

- Dimension 1—flexibility,
- Dimension 2—assistance,
- Dimension 3—travel burden, and
- Dimension 4—dependability.

Dimension 1 is associated with travel modes that offer flexibility in traveling to multiple destinations without any difficulty. Most highly correlated with Dimension 2 is the assistance attribute. Dimension 3 is a complex dimension termed travel burden. It correlates most highly with the constructs of sensitivity and understanding and friendly and courteous drivers. Minimal effort in the travel environment is again an important dimension on which travel mode preferences are formed. Dimension 4 is most highly correlated with the dependability attribute. Dependability is interpreted as meaning

TABLE 6 GROUP 2: CORRELATIONS BETWEEN ATTRIBUTES AND MDU PREFERENCE DIMENSIONS

	Dimension			
	1	2	3	4
Independence	0.28	0.37	0.63	–0.37
	0.26	0.20	0.06	0.20
Convenience	0.27	–0.41	0.48	–0.56
	0.27	0.17	0.13	0.09
Personal attention	0.26	0.39	0.58	–0.28
	0.28	0.19	0.08	0.26
Flexibility	0.60	–0.37	0.05	–0.31
	0.07	0.20	0.45	0.24
Comfort	–0.20	0.32	0.68	–0.67
	0.32	0.24	0.04	0.04
Dependability	–0.13	–0.50	0.42	–0.88
	0.38	0.12	0.17	0.00
Availability	–0.18	–0.54	–0.49	0.27
	0.34	0.10	0.13	0.27
Privacy	0.56	0.51	0.29	–0.11
	0.09	0.11	0.25	0.40
Cost of travel	0.33	0.40	–0.49	–0.07
	0.22	0.18	0.12	0.43
Assistance	0.00	0.77	0.50	–0.17
	0.49	0.02	0.12	0.35
Suitability	0.24	0.76	0.32	0.12
	0.29	0.02	0.24	0.39
Frequency of service	0.14	0.01	0.07	–0.69
	0.38	0.49	0.43	0.04
Sensitivity and understanding	0.11	0.22	0.70	–0.39
	0.40	0.31	0.03	0.19
Friendly and courteous drivers	–0.31	–0.10	0.72	–0.74
	0.24	0.40	0.03	0.02

NOTE: The second number in each cell is the probability of the correlation coefficient's being equal to zero.

prompt arrival at origin and destination and availability on a regular basis.

The preference structure of Group 1 and Group 2 represents more of a concern with modal accessibility and effort in the travel environment.

Group 3

Two dimensions of travel mode preference characterize the minor disabilities group (Table 7):

- Dimension 1—level of service and
- Dimension 2—cost of travel.

The minor disabilities group is a mobile one by comparison to the more disabled groups. The dimensions that underlie travel mode preference are simple when compared to those of other groups. Dimension 1 is the most complex of the dimensions and is labeled a level of service dimension. It is a factor composed of comfort, availability, assistance, and independence attributes. Most highly correlated with Dimension 1 is the comfort attribute. Dimension 2 highlights a preference for travel modes that are inexpensive.

TABLE 7 GROUP 3: CORRELATIONS BETWEEN ATTRIBUTES AND MDU PREFERENCE DIMENSIONS

	Dimension	
	1	2
Independence	0.70	−0.03
	0.03	0.47
Convenience	0.10	−0.00
	0.40	0.49
Personal attention	0.56	0.01
	0.09	0.49
Flexibility	−0.28	−0.01
	0.26	0.48
Comfort	0.82	−0.12
	0.01	0.39
Dependability	0.24	−0.06
	0.30	0.28
Availability	−0.80	0.28
	0.01	0.26
Privacy	0.39	−0.04
	0.19	0.46
Cost of travel	0.24	0.45
	0.29	0.15
Assistance	0.79	−0.07
	0.01	0.43
Suitability	0.49	0.00
	0.12	0.49
Frequency of service	0.38	0.24
	0.20	0.29
Sensitivity and understanding	0.48	−0.12
	0.13	0.39
Friendly and courteous drivers	0.52	−0.08
	0.11	0.42

NOTE: The second number in each cell is the probability of the correlation coefficient's being equal to zero.

Group 4

Two dimensions of travel mode preference provide the best fit for the visually impaired group (Table 8):

- Dimension 1—cost of travel and
- Dimension 2—level of service.

For the members of Group 4, the broader dimensions of travel mode preference are also of a reduced complexity. Dimension 1 is the straightforward attribute of cost of travel. Dimension 2 is primarily associated with the convenience and flexibility attributes. The visually impaired prefer travel modes that inexpensive and offer high levels of service in the travel environment.

TABLE 8 GROUP 4: CORRELATIONS BETWEEN ATTRIBUTES AND MDU PREFERENCE DIMENSIONS

	Dimension	
	1	2
Independence	−0.50	0.24
	0.12	0.29
Convenience	−0.03	0.86
	0.46	0.00
Personal attention	−0.45	0.18
	0.15	0.34
Flexibility	0.11	0.86
	0.40	0.00
Comfort	−0.54	0.08
	0.10	0.42
Dependability	−0.12	0.76
	0.39	0.02
Availability	0.40	0.12
	0.18	0.39
Privacy	−0.39	0.15
	0.18	0.37
Cost of travel	−0.73	−0.00
	0.02	0.49
Assistance	−0.60	−0.34
	0.07	0.22
Suitability	−0.45	−0.32
	0.15	0.23
Frequency of service	−0.63	0.52
	0.06	0.11
Sensitivity and understanding	−0.26	0.25
	0.27	0.29
Friendly and courteous drivers	−0.28	0.37
	0.26	0.20

NOTE: The second number in each cell is the probability of the correlation coefficient's being equal to zero.

Group 5

The preference structure of the no disabilities group is represented by four dimensions (Table 9):

- Dimension 1—level of service,
- Dimension 2—availability,
- Dimension 3—flexibility, and
- Dimension 4—cost of travel.

Dimension 1 scales the travel mode preferences in terms of their level of service performance attributes. Dimension 2 scales travel mode preferences that are more readily available, especially for emergencies and at pick-up points for return home journeys. Dimension 3 highlights a preference for travel modes taking members where they want to go. Preference for inexpensive travel modes (Dimension 4) continues to be of importance.

For the predominantly elderly and mobile members of Group 5, the broader dimensions of travel mode preference indicate a

TABLE 9 GROUP 5: CORRELATIONS BETWEEN ATTRIBUTES AND MDU PREFERENCE DIMENSIONS

	Dimension			
	1	2	3	4
Independence	0.69	−0.50	−0.03	−0.00
	0.40	0.12	0.47	0.49
Convenience	−0.82	0.16	−0.36	−0.37
	0.01	0.36	0.21	0.20
Personal attention	−0.60	−0.35	0.03	−0.05
	0.07	0.22	0.46	0.45
Flexibility	−0.52	0.37	−0.66	−0.21
	0.11	0.20	0.05	0.32
Comfort	−0.65	−0.49	0.22	0.16
	0.05	0.12	0.31	0.35
Dependability	−0.81	0.13	−0.22	−0.18
	0.01	0.38	0.31	0.34
Availability	0.30	0.87	0.02	−0.04
	0.25	0.00	0.47	0.46
Privacy	−0.39	−0.34	−0.20	0.18
	0.18	0.22	0.32	0.34
Cost of travel	−0.26	−0.07	−0.22	0.75
	0.28	0.43	0.31	0.02
Assistance	−0.27	−0.66	0.33	0.35
	0.27	0.05	0.23	0.22
Suitability	−0.11	−0.47	0.21	0.30
	0.40	0.14	0.31	0.25
Frequency of service	−0.80	0.04	−0.24	0.41
	0.01	0.46	0.30	0.17
Sensitivity and understanding	−0.58	−0.27	0.07	−0.01
	0.08	0.27	0.43	0.41
Friendly and courteous drivers	−0.73	−0.11	0.19	−0.09
	0.03	0.40	0.33	0.41

NOTE: The second number in each cell is the probability of the correlation coefficient's being equal to zero.

strong preference for travel modes that make traveling easy and pleasant and that offer high levels of service. As with the minor disabilities group and the visually impaired group, the members of Group 5 show less of a preference for modal accessibility in the travel environment.

Several comments are relevant based on emerging patterns in the derived travel mode preference dimensions. The occurrence of the cost of travel dimension across preference structures for the less disabled groups reinforces part of the repertory grid analysis findings. Despite the inexpensive nature of public travel services available to the elderly and handicapped in Columbus, Ohio, the cost dimension is an important variable when deciding travel mode preferences—a consistent finding considering that the majority of the sample population's sole means of support is a federal pension.

The ubiquitous nature of the flexibility preference dimension confirms the preference expressed by respondents during the interview for travel modes to take them where they want to go when they want to go. The respondents also expressed a strong preference for travel modes to wait for individuals to finish their business and then return them to their residence. Much concern was expressed over certain travel modes that tend to leave the shopping or medical center after drop-off only to return following a long waiting period for the individual. This notion is probably linked to a greater need for security when traveling. The research of Miller (*13*) and Gauthier (*10*) indicated that certain components of the flexibility dimension are important in travel mode preference decisions, for example, more control over route scheduling and control over arrival and departure times. Travel modes that are most preferred for their flexibility fall into two categories: public (regular bus, Project Mainstream) and private (automobile-passenger, automobile-driver).

The dimensional structures identified for each group are also indicative of several relationships between personal physical disabilities and travel mode preference. First, those groups with minor or no physical disabilities possess preference sensitivities for travel modes associated with level of service and low-cost attributes. These preference sensitivities represent more of a concern with travel modes that make traveling easy and pleasant and provide mobility. They reveal less of a concern with modal accessibility. Relative freedom from physical disabilities allows for a preference structure that ranks travel modes in terms of whether they can meet minimal effort and mobility requirements. Reported travel mode preferences, from the ALSCAL-4 MDU analysis, indicate that it is the fixed-route bus service and the automobile that meet the screening criteria. Predicted preferences indicate that a taxi service and a privately operated wheelchair-lift-equipped van service would also meet the criteria of good service, minimal effort, and mobility.

Second, the preference structure of the more physically disabled members of Group 1 and Group 2 is indicative of a concern for travel modes associated with modal accessibility and minimal effort in travel. For both groups, the provisions of access and, in particular, the availability of personal assistance on and off the vehicle are important criteria in the rank ordering of travel mode preference alternatives. Access to travel modes is imperative in overcoming the constraints imposed by severe physical disabilities and by confinement to a wheelchair.

The most preferred travel modes for the more physically disabled groups are Project Mainstream and the automobile-passenger travel mode. Traveling as a passenger in an automobile driven by family members, friends, or volunteers or in a wheelchair-lift-equipped van service provides high levels of personalized assistance, flexibility, and dependability of service. These attributes also favor a travel environment in which minimal effort is expended. Predicted preferences (Magic Carpet Service and taxi) are also for travel modes that possess similar attributes.

Of interest to the wheelchair users is the travel mode that is neither most preferred nor predicted as a first preference—Project Mainstream Van Service. At the time of the interview survey, Project Mainstream was perceived to be unsatisfactory on the wheelchair users' criteria of flexibility, assistance, travel burden, and dependability dimensions. As a dial-a-ride service, Project Mainstream was primarily implemented for wheelchair-confined individuals. However, since its implementation, and up to the time of the interview survey, the service had suffered from scheduling and supply and demand problems (i.e., inability to secure regular service) (*21*). These problems were all articulated by the wheelchair users during the interview survey. Most indicated that level of service would need to be markedly improved before they would use the service.

In order for Project Mainstream patronage to increase, the service should be upgraded along the dimensions used by the wheelchair users to determine the formation of travel mode preferences. Other potential patrons of Project Mainstream, the severely disabled, would also benefit from increased service standards (i.e., the service would become a viable alternative to

the automobile-passenger mode on the dimensions of accessibility and minimal effort.

It must be noted that since completion of the interview survey, the service standards of Project Mainstream have been improved by COTA. The result has been a dramatic increase in patronage, and a more positive perception of and preference for Project Mainstream now exist among the elderly and handicapped community in Columbus, Ohio (*7*). In addition, a new subsidized service, termed Project Mainstream Taxi Service, was introduced by COTA in 1983.

SUMMARY AND POLICY IMPLICATIONS

The objective of this research was to obtain a clearer understanding of the relationships between personal physical disabilities and the formation of dimensions of travel-mode-preference alternatives. To this end, elicited personal constructs were examined and broader dimensions of travel mode preference were latently derived for five internally homogeneous groups of the elderly and handicapped sample population.

Latently derived dimensions for the five groups highlighted preference sensitivities toward accessibility, travel burden, level of service, and cost concerns in the process of travel-mode-preference formation. These sensitivities were found to vary depending on the levels of personal physical disabilities. In essence, it is the varying levels of physical disabilities that define not only the dimensions of travel mode preference, but the way preferences for travel mode alternatives are formed in the second stage of the travel choice decision-making process. Preference sensitivities were found to be similar in their components to perceptual sensitivities.

The findings of this study have several policy implications for the elderly and handicapped. First, the sample population's broader concern with accessibility, travel burden, level of service, and cost in travel-mode-preference decision making provides policy makers and planners with criteria to use in establishing and improving travel services to the elderly and handicapped. Furthermore, the attributes that form the respective preference dimensions provide detail on specific components of a "preferred" or "ideal" transportation system for the elderly and handicapped.

For Columbus, Ohio, the sample population does not perceive the need for a markedly different transportation system. Mode use statistics and travel mode preferences for the automobile-passenger, COTA bus, and Project Mainstream modes are indicative of "ideal" travel services. However, the more disabled group members perceive necessary improvements to those attributes that enhance their accessibility to the demand-responsive travel service.

Second, the early problems of supply and demand for Project Mainstream service suggest that other frequently used travel modes should be investigated. For example, the automobile-passenger mode is most frequently used by the sample population. Family members, friends, or volunteer workers provide a vital function in meeting the travel needs of the elderly and handicapped on a demand-responsive basis. A service strategy that incorporates the automobile-passenger mode will increase mobility and travel services. A further alternative, as suggested from the predicted preferences, is a service strategy that subsidizes the use of demand-responsive taxi services. In Columbus, Ohio, Project Mainstream Taxi Service was established to provide such a demand-responsive alternative.

A final implication exists for transit authorities with travel service provision responsibilities to the elderly and handicapped. Such agencies must realize that the elderly and handicapped population that they serve is a heterogeneous one. There are varying levels of personal physical disabilities that are associated with internally homogeneous groups displaying diversity in travel behavior. Only when this heterogeneity is clearly identified can transit agencies implement responsive and equitable service strategies that reduce the burden of travel and improve overall accessibility and levels of service.

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