Action Space Formation: A Behavioral Approach to Predicting Urban Travel Behavior

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A conceptual framework for examining the process of action space formation, a process important in the understanding of urban travel behavior in urban areas, is delineated. Urban travel behavior is considered a direct product of the action space of households living within urban areas. Action space formation is considered the outcome of a two-stage process. The first centers on the relationships between the householders' residential location, length of residence, socioeconomic attributes, objective urban spatial structure, and travel preferences and perception of the urban environment. The second stage treats the interrelations of travel preferences, perception of the urban environment, and the action space formation process. An analytical framework, designed to test and calibrate the conceptual framework, is presented. Preliminary empirical findings related to the structure of aggregative action spaces of two quite different urban neighborhoods are presented. Differences in the structure of route preferences in a shopping context for the two neighborhoods are discussed. Linkages between the action space of an urban household and its urban travel behavior are defined in the empirical analyses.

•THIS PAPER relates the concept of action space formation to urban travel behavior and describes several empirical analyses considered useful in constructing a behavioral model of action space formation, which has as one of its outputs the specification of urban travel behavior. Hence, the concept of action space seems to be extremely useful when applied to the problem of understanding and predicting urban travel patterns.

Before proceeding, we shall define several basic concepts used throughout the paper. The term "objective spatial structure" refers to the location of a household relative to the actual locations of all potential activities and their associated objective levels of attractiveness within an urban area. "Action space" is the collection of all urban locations about which the individual has information and is the subjective utility or preference he associates with these locations. The subjective utility or preference is evaluated with regard to both potential and actual travel behavior. Geometrically, action space is characterized by two components: first, its spatial extent as defined by the set of locations; and, second, a generalized surface (both piecewise and continuous) specifying the utility or preference level associated with each location. This definition is a slight reformulation of the concept as originally presented by Wolpert (1). An individual's "activity space" is defined as the subset of all urban locations with which the individual has direct contact as the result of day-to-day activities. The term is similar to the notion of activity system put forth by Chapin (2) and Hemmens (3). Geometrically, activity space is characterized as a surface (again both piecewise and continuous) descriptive of the intensity of actual travel behavior over portions of the action space.

Although the individual theoretically has access to a broad range of environmental information spanning local to international levels, usually only a limited portion of the urban environment is relevant to this travel behavior in any given context. Even though

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the individual's action space is limited spatially, a meaningful examination of its formation is likely to include consideration of a wide range of travel behavior (e.g., the journey to work, shopping, visiting neighbors, etc.) and cannot ignore the individual's perception of the objective spatial structure of his physical, economic, and social environment within which this behavior takes place.

The degree to which the individual's travel behavior is in equilibrium with the objective spatial structure of the city depends upon his ability to collect and assimilate information concerning it. Differences in race, sex, education, income, and social status are all likely to represent early and salient factors contributing to the individual's efficiency in receiving and weighing such information and may also induce distinctive biases in his travel behavior. For example, urban ghetto life would seem to generate a cramped view of the urban environment partly because of the spatial concentration of environmental experiences (4).

Because no two individuals perceive the city from exactly the same point simultaneously and because each bases his interpretation of information gleaned from the urban environment on past experience, action spaces vary from person to person. Although perceptions and action spaces are to a degree individualistic, there is reason to suggest that they are shared, to a large extent, by like groups of people. For example, the formation of the individual's action space and its manifestation in urban travel behavior is almost certainly affected by his group memberships, his position in social networks, his position on one of his divergent life cycles, and his spatial location with respect to potential trip destinations in the environment. Obviously, the latter (generally his residence) is the primary node in any action space, as it is in any study of urban travel behavior. Through personal observation, the individual is likely to be more familiar with local areas (the areas in the vicinity of his residence and his workplace, in particular) than those points at greater distances from him and about which available information is limited. Thus, a person's environmental perception is conditioned only in part by the nature of the objective milieu itself.

Isard (5) has suggested that variations in individual space and time preferences are so great as to preclude any economic rationalization of individual travel behavior. Thus far, Isard's pessimism seems to have been justified in that deterministic economic models, with their built-in assumptions of economic rationality, have been noteworthy for their lack of success in accounting for spatial behavior, except at a highly aggregative level. It would appear appropriate, therefore, to adopt a behavioral approach that examines the formation of the individual's action space and his resulting travel behavior as a function of his socioeconomic characteristics, his cognitive images of the urban environment, and his preferences for travel.

The individual's perception cannot be viewed as being static, but rather as changing via a complex learning process. Given socioeconomic constraints, and provided that the individual does not change his place of residence, one would expect that as an individual modifies his perception of his environment by traveling within it and by communicating with his peers about it, his travel behavior would approach spatial equilibrium and "rational economic behavior." To expect such behavior, however, would also presuppose that the objective spatial structure itself does not change. In fact, the objective spatial structure and its components (i.e., retail structure, location of employment opportunities, temporal differences, residential quality, etc.) are constantly undergoing change that results in the continuous reordering of the perceived urban spatial structure.

Technological change also plays an important role in extending an individual's action space and in modifying its morphology; but, at the same time, such change impedes the tendency of the individual's travel behavior toward the economically rational. An appropriate example is the increase in the use of private transportation, which has enabled the individual to extend the perimeter of his action space. At the same time, however, continued increase in the use of this mode of transportation has affected spatial distortions and place disutilities within the areally increased action space: the penalties are congestion with all its concomitant psychological and physiological effects. Therefore, continuous technological change and perceptual lags would seem to prevent the individual from achieving spatial equilibrium and economically rational behavior, although he may approach these states. Nevertheless, an individual's perception or cognitive image of the city should be in equilibrium with his action space, the one being a satisfactory predictor of the other.

RELEVANCE OF ACTION SPACE FORMATION RESEARCH TO STUDIES OF URBAN TRAVEL BEHAVIOR

The nature of urban travel patterns and the factors that condition them have prompted numerous research endeavors. An examination of these travel studies reveals a divergence in the factors that are reported to be of greatest value in forecasting travel patterns. Although this divergence may be the result of the varying purposes for which these studies were conducted and of the aggregate data upon which most are based, the factors nonetheless are inadequate for providing a clearly articulated empirical basis for the development of a theory of urban travel behavior. Attempts to use variables that have been shown to be related statistically to urban travel at the aggregate level have been almost universally unsuccessful at the household level. This failure is not surprising; factors that are important conditioners of mass group behavior (such as employment rate, median income, etc.) are devoid of behavioral meaning at a less aggregated level.

Urban activities provide the impetus for movement. An individual's perception of their desirability and location form the basic psychospatial milieu within which action space formation takes place. Thus, the location and spatial structure of urban activities are important to the modeling and understanding of action spaces. Clearly, a better understanding of the urban household's travel behavior demands that more research be directed toward discerning fundamental processes underlying this behavior. Action space formation is one such process.

Research concerned with action space formation would be an important initial step in ascertaining the impact of modifications in the location of activities and facilities in cities (e.g., urban renewal or expressway construction) upon the urbanite's cognitive image of, and travel behavior within, the modified urban system. For example, what effect does the construction of an expressway through a low-income, central-city area have upon the action spaces of those residents in the area relative to its impact on the action spaces of suburban commuters? What modifications of the urban environment maximize the spatial extent of action spaces summed over the entire metropolitan population? Research directed toward providing a framework on the basis of how such questions can better be posed and answered is of fundamental importance to both the social theoretician and the urban transportation planner.

Very few behavioral scientists have attempted to investigate systematically the formation of individual action spaces relative to various types of behavior. Wolpert's investigations (1) into the relationship between action space and the decision to migrate would seem to provide a useful framework for research into other areas of spatial behavior. However, the work of other social scientists—sociologists and social psychologists, in particular—also contains several useful insights into the formation of the individual action space and the extent to which these are shared by groups of people (6). The importance of social groups in affecting an individual's behavior has been studied especially well (7). Studies of the networks of interpersonal contacts have also provided empirical information which suggests a close relationship between social and spatial propinquity (7, 8). The flow of information through the networks of interpersonal communication is the basis for the images shared by individuals in social networks. Although group membership fosters the development of shared images, it may also inhibit the flow of information to the individual from other sources. In this regard, Deutsch (9) has commented on the way people may be "marked off from each other by communicative barriers, by 'marked gaps' in the efficiency of communication."

Some investigations, such as Lynch's empirical examinations (10) of how people in several areas perceive the spatial structure of their home cities, are highly suggestive of research hypotheses. The present state of knowledge is meager, however, concerning how the actual location of activities and the locational relationships between them, an individual's cognitive image of these activities and their locations, and travel preferences interact to form the action space.

CURRENT RESEARCH

There are several ways in which one could examine household action spaces and isolate those factors that are important inputs to their formation and change. The approach selected here is, at the outset, decidedly empirical because it involves collecting a considerable amount of information at the household level and testing sets of interrelated hypotheses. The data collection and hypotheses testing, however, is governed by the conceptual framework shown by Figure 1.

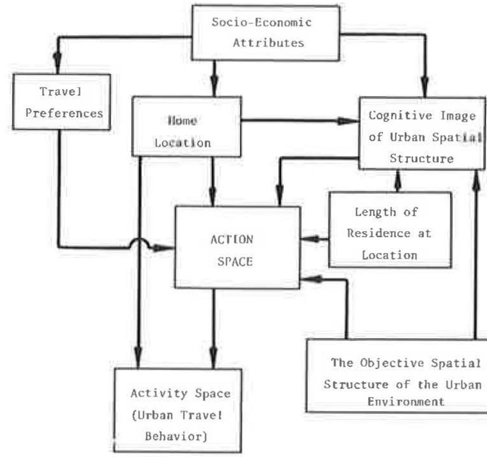

Figure 1. Conceptual model for action space.

The research currently being conducted consists of three closely related tasks:

1. The elucidation and testing of a behavioral model whose inputs interact to form an urban resident's action space and determine its spatial structure and extent, thereby defining the outer limits of likely travel within the urban area.
2. The definition and measurement of the morphology of action space and of cognitive images of the city so as to facilitate testing of theoretical hypotheses.
3. The development of methods for evaluating the effects of a changing objective spatial structure on the householder's environmental perception and his preferences for various urban travel activities.

Methodological Considerations

Two compact residential areas in Cedar Rapids, Iowa, constitute the study areas. These were selected with two considerations in mind: first, it was deemed important to proceed with interviews both in an area where the ratio of external to internal trips was high and in one where this ratio was low; and, second, it was necessary to contrast two populations from areas of quite different, but reasonably internally homogeneous, socioeconomic characteristics. The data that formed the basis of the study were obtained from the 1965 Origin-Destination Survey of the Cedar Rapids metropolitan area and from city census information. The areas selected were a low-income area in the central portion of the city, known locally as the Oak Hill-Jackson area, and an upper-middle-income area on the western perimeter of the city, known locally as Cedar Hills.

The interviewing phase of the investigation uses a pretested questionnaire designed to elicit the following information from approximately 200 sampled households having access to private transportation in each of the two areas:

1. Socioeconomic characteristics and group memberships;
2. Relative locational attitudes including past and present job location and locations of friends and relatives in Cedar Rapids;
3. Habitual routes of travel for the journey to work and for certain types of shopping;
4. Preferences for characteristics of travel, destinations, routes, and general trip structure;
5. The spatial extent and structure of the household's action space;
6. The perceived range of spatial choice in selected shopping situations; and
7. Perceptions of residential quality and shopping facilities in subareas of the metropolitan area.

This investigation is not concerned with the householder's composite image of Cedar Rapids. (Other studies, such as Lynch's (10), have discussed this image.) Rather, the present study is concerned with the way individuals structure their preferences for spatial interaction in varying travel and shopping contexts (e.g., shopping trips, etc.). The interest in cognitive images of the environment focuses on the individual's spatial ordering of Cedar Rapids in terms of residential quality and shopping opportunities in general, as well as on his perception of individual retail establishments in terms of locational and qualitative attributes. This approach is taken because preferences and perceptions are used in an analytical rather than a descriptive manner—analytical, in the sense that this information will be input into a model of action space formation.

One problem that became immediately apparent was the operational articulation of the concept of action space. Because it was desirable for the concept to reflect not only the actual travel behavior of the individual, but also potential travel behavior, action space was operationally defined to be the area with which the individual perceives himself to be familiar. The structure of an individual's action space is defined by the correlation between areas of varying levels of perceived familiarity. To derive these measures, each sampled individual was confronted with a map dividing the Cedar Rapids metropolitan area into 27 subareas; and he was asked to indicate, on a five-point scale, the level of his familiarity with each subarea. These ordinal familiarity responses for each of the two samples were then transformed to an interval scale by a psychological scaling technique described in the following section. It was then possible to determine the basic structural dimensions of the aggregate action spaces of both sampled populations by employing "latent structure" or factor analytic procedures. The vectors of factor scores on each of the basic dimensions specify the location and structure of each individual's action space relative to the aggregate action space of his residential group.

Given the derived vectors depicting action spaces, it is necessary to operationally define the components related to action space formation shown by Figure 1. Socioeconomic attributes, home location, and length of residence for each household are obtained directly. Measures of the "objective spatial structure of the urban environment" are obtained from exogenous data sources such as Polk's Directory, 1966; 1968 school census materials; and several inventories developed in the 1965 Cedar Rapids Transportation Study. "Travel preferences" and "cognitive image of urban spatial structure" are both vectors of derived measures and, hence, require some elaboration.

The individual's travel preferences are derived from three sets of responses to questions in which the individual indicates the level of importance or preference for selected destination, travel, and route characteristics in varying travel contexts. Travel preferences include consideration of both time and distance. Responses were transformed into interval scale measurements and were analyzed as to levels of dimensionality by employing factor analytic procedures.

The measurement of cognitive image of urban spatial structure is on two levels. On the first, the individual evaluates his actual shopping destinations with respect to a given set of attributes. Because several of the attributes relate to the location of a destination, it is possible to ascertain the extent to which subjective destination characteristics distort objective travel distances and locational settings. On the second level, the individual evaluates residential quality and shopping facilities in each subarea of his action space. Evaluations are constrained to a five-point scale of "goodness" and are analyzed in the manner suggested.

PRELIMINARY EMPIRICAL FINDINGS

Before full-scale model construction can begin, action space and the salient inputs to its formation must be identified quantitatively. The empirical research deals with the aggregate structures of the action spaces of the two sampled populations and the aggregate structures of their preferences for types of routes in a multiple-purpose shopping context.

Scaling Procedures

The majority of the information was elicited from respondents in the form of a constrained-response questionnaire allowing the respondent to subjectively rate areas and variables on a categorical scale of 0 to 4. For example, an individual's familiarity with an area would range between 0 (unfamiliar) and 4 (very familiar). Given the need for interval-scaled data in the majority of the analyses and in the actual model-building effort, it was necessary to transform the ordinal response data. This was accomplished by the application of a multidimensional scaling technique derived from Thurstone's law of categorical judgement. The methodology of this study is an adaptation of the work of Torgeson (11) and relies heavily on the modifications made by Peterson (12). Computer programs used in this analysis are variations of those written by Wachs (13).

In using the method, it is assumed that there is a psychological continuum that defines for a respondent the attribute he is considering. An attribute in question may be "importance," "goodness," "quality," "familiarity," etc. When the respondent considers a variable, a discriminal process enables him to place his image of that variable at a point on the psychological continuum corresponding to the perceived quantity of the attribute in question. The discriminative process is assumed to be probabilistic. Therefore, the respondent's placement of a value along the continuum will not be the same on every trial of an experiment, but instead will be defined by a Gaussian distribution on the continuum. The true value of the subject's response is taken to correspond to the mean of the Gaussian distribution of his responses. Each variable rated will have a particular mean response and dispersion about the mean.

For the purpose of this analysis, it is also assumed that the psychological continuum can be partitioned into a chosen number of ordered categories. If follows that a given category boundary will not always be perceived at a unique point on the continuum. Its location is also assumed to be defined by a Gaussian probability distribution with each category boundary having its own mean and dispersion. The operational problem, then, is to estimate the locations of each of the category boundaries and to assign each ordinal response to the midpoint location of that category on a psychological continuum, and to thereby convert the ordinal responses to interval-scaled values. As Torgeson (11) points out, this can be accomplished if one can assume that the location of any given category boundary is independent of the variables under consideration, and that the variability of the location of any given category boundary is constant across variables. These assumptions are met whenever the respondent maintains the same psychological continuum for the attribute under consideration over all variables. This does not appear to be unrealistic.

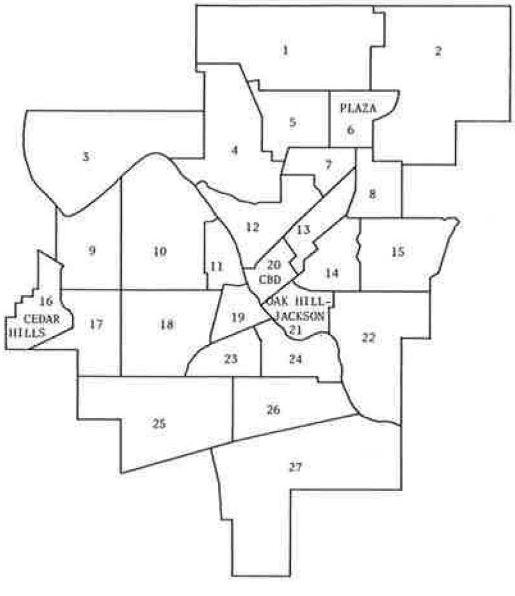

Figure 2. Subareas of metropolitan Cedar Rapids evaluated by respondents.

Aggregative Action Spaces for the Two Samples

As noted previously, the action space of an individual is operationally defined as the area with which he perceives himself familiar. (For the location of each of the 27 subareas evaluated, see Fig. 2.) Hence, it includes those areas within which the majority of his spatial behavior takes place as well as those that encompass potential interaction areas. Because the level of an individual's familiarity varies from one subarea to another, the areal structure of a composite action space for a residential community, such as those in this study, can be defined realistically by the correlations between areas of varying levels of perceived familiarity. If action spaces are highly individualistic and do not exhibit systematic regularities, then such correlations will be low and the concept of action space will be of dubious generality in modeling urban travel behavior. Therefore, the first task was to examine the common dimensions of variability in the spatial structures of the action spaces for each of the two sampled populations.

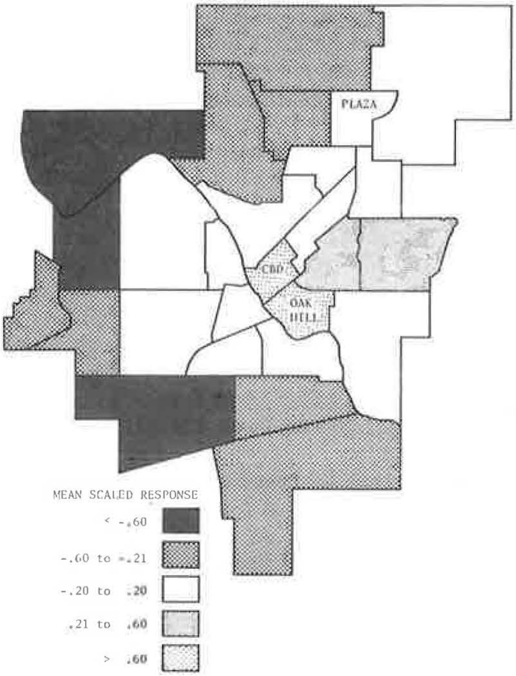

Figure 3. Familiarity-mean scaled responses—Oak Hill-Jackson.

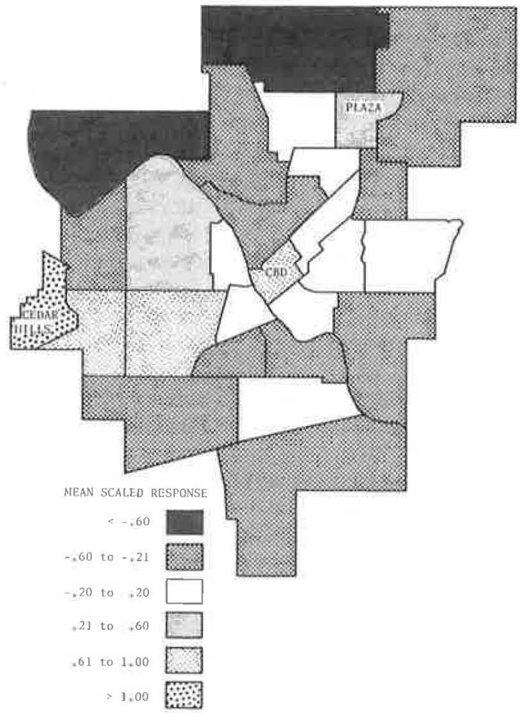

Figure 4. Familiarity-mean scaled responses—Cedar Hills.

The ordinal familiarity responses for the 27 subareas of metropolitan Cedar Rapids were transformed to an interval scale for each of the two samples. The mean scaled familiarity responses for the sample in the low-income, central-city residential area, Oak Hill-Jackson, are shown in Figure 3. As can be seen, the aggregative action space of this group appears, in general, to be characterized by a pronounced familiarity with the home area and the adjacent central business district (CBD) and by an increasing unfamiliarity with increasing distance from the home area. A major exception to this generalization is a high level of familiarity with areas comprising the Northeast Corridor, which is traversed by the most important thoroughfare in the city. Clearly, levels of familiarity are related to urban spatial structure as perceived by the respondents.

Similarly, Figure 4 shows the mean scaled familiarity responses of the sample from the middle-income residential area, Cedar Hills. The aggregate action space of this residential group differs from that of the sample from the low-income, central-city area, primarily in the more pronounced overall familiarity and in the linear rather than modal pattern of familiarity levels. Areas of highest familiarity are the home area and those in the direction of the CBD, the CBD itself, and that area containing the major outlying shopping plaza. In general, familiarity decreases with distance from the home-CBD-shopping-plaza axis of familiarity. It should be noted that the same general elements of urban spatial structure were evaluated similarly by both sets of respondents. Because of the location of the home in relation to those elements, however, the pattern of mean scaled familiarity was circular in the case of Oak Hill-Jackson and linear in the case of Cedar Hills.

To assess the extent to which there are common dimensions of variability in the spatial structures of the composite action spaces for each of the two sampled populations and to identify the spatial dimensions common in each, the matrices of correlations representing familiarity between areas for each sample were subjected to principle components analyses with subsequent varimax rotation. In the resulting factor structures, each of the 27 areas had a high factor loading on one and usually only one of the basic spatial dimensions of variability in familiarity extracted (see Tables 1 and 2). Therefore, the variation accounted for by each basic dimension was composed primarily of systematic covariations in familiarity within clusters of areas.

For the Oak Hill-Jackson sample, six dimensions of variability in familiarity which accounted for 67 percent of the total variance in between-area familiarity were extracted (see Table 1). These are shown in Figure 5. The areal partitioning of the metropolitan area accomplished through this analysis resulted in contiguous and nonoverlapping groupings of subareas. The resulting spatial dimensions of variation in familiarity in terms of decreasing levels of "explained" variation can be characterized as follows:

1. An area of uniformly moderate familiarity;
2. The home area and maximum familiarity;
3. A northern area of uniform unfamiliarity;
4. A western area of uniform unfamiliarity;
5. An area of decreasing familiarity with increasing distance to the south of the home area; and
6. A concave surface of familiarity peaking in the CBD and the major outlying shopping plaza.

In the Cedar Hills sample, the principle components analysis resulted in the extraction of seven dimensions for the aggregate action space (Fig. 6). These dimensions account for 69 percent of the between-area levels of familiarity (see Table 2). With only one exception, the areas comprising these basic dimensions are contiguous and

TABLE 1

AGGREGATE STRUCTURE OF THE OAK HILL-JACKSON ACTION SPACE RESULTING FROM THE VARIMAX FACTOR STRUCTURE

Subarea[a]	Loadings on Each Factor[b]					
	1	2	3	4	5	6
1			0.644			
2			0.542			
3			0.766			
4			0.631			
5	0.367		0.692			
6						0.603
7			0.450			0.560
8			0.438			0.530
9				0.710		
10	0.760					
11	0.770					
12	0.447					
13	0.408					0.482
14						0.710
15					0.361	0.703
16				0.723		
17				0.749		
18	0.606			0.392		
19	0.456	0.354				
20						0.731
21		0.842				
22		0.544			0.505	
23	0.409				0.568	
24					0.573	
25				0.439	0.623	
26					0.688	
27				0.369	0.657	
Percent of variance	43.1	6.6	6.3	4.0	3.9	3.3

[a]For the location of subareas, see Figure 2. [b]Only factor loadings greater than 0.35 are shown.

TADLE 2

AGGREGATE STRUCTURE OF THE CEDAR HILLS ACTION SPACE RESULTING FROM THE VARIMAX FACTOR STRUCTURE

Subarea[a]	Loadings on Each Factor[b]						
	1	2	3	4	5	6	7
1					-0.766		
2					-0.809		
3		0.765					
4		0.486					
5				-0.436	-0.503		
6				-0.854			
7				-0.712			
8						-0.476	0.407
9						-0.708	
10						-0.646	
11						-0.571	
12					-0.385	-0.472	
13				-0.562			
14							0.767
15							0.739
16			0.831				
17			0.657				
18	0.433		0.492			-0.366	
19	0.657						
20	0.571			-0.409			
21	0.574					-0.373	0.361
22	0.432						0.579
23	0.763						
24	0.774						
25	0.647					-0.400	
26	0.644						
27	0.665						
Percent of variance	40.7	7.2	5.1	4.5	4.1	3.6	3.4

[a]For the location of subareas, see Figure 2.

[b]Only factor loadings greater than ±0.35 are shown

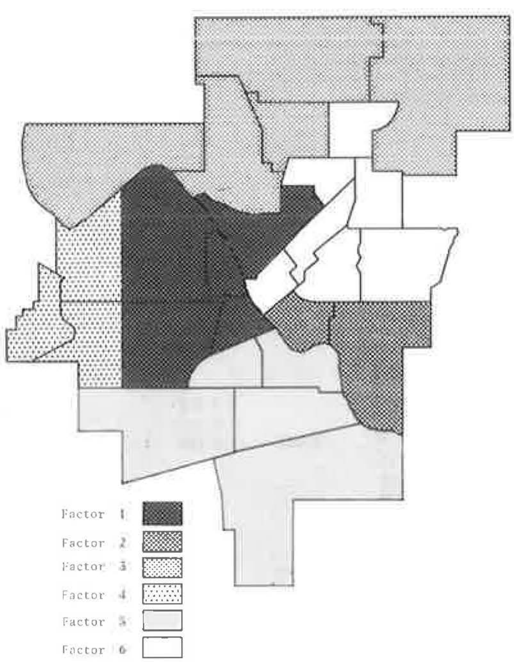

Figure 5. Familiarity factor structure—Oak Hill-Jackson.

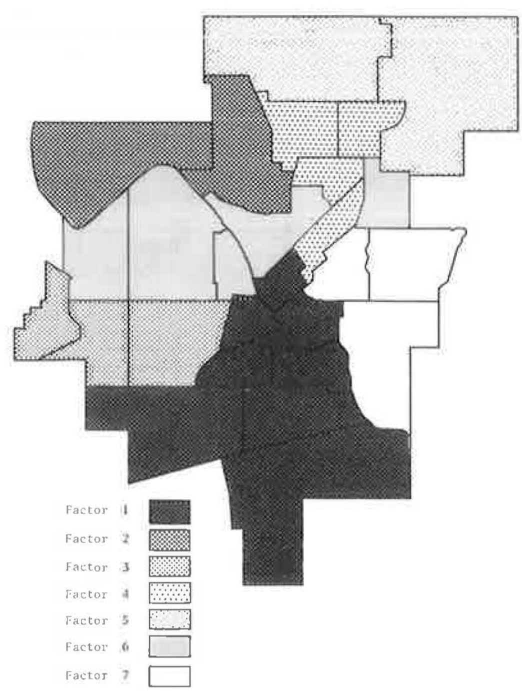

Figure 6. Familiarity factor structure—Cedar Hills.

nonoverlapping. The major dimension of variations in between-area familiarity is accounted for by variations within area 1, which is characterized by decreasing familiarity from the CBD in a southern direction. The remaining dimensions of variation in decreasing order of explained variation may be characterized as follows:

Area 2, a relatively inaccessible, low population density area of very low levels of familiarity.

Area 3, an area of decreasing familiarity out from the home area and towards the CBD.

Area 4, an area along the major thoroughfare axis characterized by increasing familiarity that peaks at the major shopping plaza.

Area 5, a northeast area of uniform unfamiliarity.

Area 6, an area of moderate familiarity to the northwest of the major familiarity axis.

Area 7, an area of moderate familiarity to the southeast of the major familiarity axis.

TABLE 3

SHOPPING TRIP ROUTE-SELECTION ATTITUDE FACTORS AND FACTOR LOADINGS—CEDAR HILLS

Factor Number and Name	Percent of Variance	Variable Name	Loading
1. Preference for less traffic	31.22	Fewer trucks and buses	+0.694
		Less automobile traffic	+0.670
		Shopping can be completed without making left-hand turns across traffic	+0.625
		Few pedestrians crossing	+0.559
		Route is safer than others	+0.535
2. Preference for convenient nonredundant route and shopping node geometry	7.52	Shopping can be completed without any doubling back or retracing of original route of travel	+0.693
		On this route it is possible to stop at more than one shopping center rather than traveling downtown	+0.676
		Most of the stores are near home on this route	+0.649
		Stores are only a short distance apart on this route	+0.608
		On this route it is possible to travel to most distant store and then do the rest of my shopping on the way home	+0.527
		It is possible to return home from the last stop in the shortest time possible	+0.492
3. Preference for steady higher speed	5.38	Pavement is smoother	+0.801
		Possible to maintain a steadier rate of speed	+0.599
		The speed limit is higher	+0.534
4. Preference for less travel time	4.91	Trip takes less time	-0.770
		Fewer stops and interruptions	-0.689
		Distance is shorter	-0.683
		Route is more direct	-0.653
		Fewer traffic lights	-0.515
		It is possible to return home from the last stop in the shortest time possible	-0.510
		The speed limit is higher	-0.483
		It costs less to drive on this route	-0.459
5. Preference for pleasant scenery	4.48	Route goes through more pleasant neighborhoods	+0.861
		The scenery is more pleasant	+0.808
6. Preference for change in scenery	3.67	On this route it is possible to return home by taking another which takes no more driving time	-0.741
		This route goes through as many different parts of the city as possible	-0.671
		On this route it is always easy to determine how far I am from my home and destination	-0.461
7. Preference for safe, major arterials	3.43	There are more lanes on this route	-0.765
		The lanes are wider on this route	-0.717
		On this route it is easy to turn off onto alternative routes, if necessary	-0.521
8. Preference for clearly marked and easily followed routes	3.27	Route is easy to follow and remember	-0.692
		Route is more clearly marked	-0.613
9. Preference for auto services along route	3.16	There are more service stations along this route	-0.774

The unexpectedly high levels of explained variation resulting from the components analyses lend further credence to the notion that individuals sharing similar residential locations in an urban area share similar images of urban spatial structure and share similar action spaces. The analyses of the responses for both the Oak Hill-Jackson and Cedar Hills samples resulted in contiguous areas representing independent dimensions of familiarity. Thus, there are probably significant subgroups in each sample with remarkably similar action spaces in terms of both spatial extent and structure. Such subgroups are hypothesized to be characterized by similarities in travel and shopping preference structures, lengths of residence, location of work place, and ethnic and socioeconomic characteristics.

That different dimensions are characterized by similar levels of familiarity is indicative of significant subgroup differences most likely based on length of residence within the Cedar Rapids metropolitan area. This result may indicate a bias generated by stages in a learning process. The learning-process influence is also suggested by the apparent arterial bias exhibited in the familiarity levels of the Cedar Hills sample population. Because Cedar Hills is a newly developed subdivision in Cedar Rapids, the sample was primarily composed of residents with only short term experiences in the

TABLE 4

SHOPPING TRIP ROUTE-SELECTION ATTITUDE FACTORS AND FACTOR LOADINGS—OAK HILL-JACKSON

Factor Number and Name	Percent of Variance	Variable Name	Loading
1. Preference for safe major arterials	27.58	Route is safer than others	+0.749
		There are more lanes on this route	+0.725
		The lanes are wider on this route	+0.690
		It costs less to drive on this route	+0.503
2. Preference for less travel time	7.63	Distance is shorter	+0.845
		Trip takes less time	+0.741
3. Preference for convenient nonredundant route and shopping node geometry	5.64	Stores are only a short distance apart on this route	+0.782
		Shopping can be completed without any doubling back or retracing of original route of travel	+0.631
		Most of the stores are near home on this route	+0.626
4. Preference for pleasant scenery	5.50	The scenery is more pleasant	-0.867
		Route goes through more pleasant neighborhoods	-0.786
		This route goes through as many different parts of the city as possible	-0.436
		On this route it is possible to stop at more than one shopping center rather than traveling downtown	-0.434
5. Preference for well-known routes with auto services available	4.85	On this route it is always easy to determine how far I am from home and from my destination	+0.704
		There are more service stations along this route	+0.626
		On this route it is possible to return home by taking another which takes no more driving time	+0.519
6. Preference for less congestion and higher speed	4.48	The speed limit is higher	+0.646
		Shopping can be completed without making left-hand turns across traffic	+0.590
		Fewer pedestrians crossing	+0.502
		Less automobile traffic	+0.503
7. Preference for clearly marked routes	4.18	Route is more clearly marked	+0.680
		On this route it is possible to travel to most distant store and then do the rest of my shopping on the way home	+0.617
		Route is easy to follow and remember	+0.513
		On this route it is easier to turn off onto alternative routes if necessary	+0.475
8. Preference for steady speed	3.60	Easier to see what is ahead along this route	+0.698
		Possible to maintain a steadier rate of speed	+0.680
		Pavement is smoother	+0.672
		Route is more direct	+0.659
		On this route it is easier to turn off onto alternative routes if necessary	+0.449
9. Preference for less traffic	3.20	Fewer trucks and buses	+0.750
		Fewer stops and interruptions	+0.591
		Less automobile traffic	+0.517
		Fewer traffic lights	+0.468
		Fewer pedestrians crossing	+0.456

metropolitan area. This arterial bias, of course, is also indicative of the marked influence of the transportation network and, hence, the objective spatial structure of urban environments on action space formation.

Attitude Toward the Selection of Routes to Shopping Destinations

The analysis of the preferences for route selection in a multiple-purpose shopping context for both the Cedar Hills and Oak Hill-Jackson area proceeded in a manner similar to that outlined previously. The resulting factor structures derived from the route preference analysis are given by Tables 3 and 4. Nine factors accounted for 67 percent of the variance in both Cedar Hills and Oak Hill-Jackson.

Several of the factors in each of the tables are similar (see Tables 3 and 4). It is interesting, however, to note that the factor accounting for the largest amount of variance in the analysis of the responses made by the residents of the central-city community is the preference for safe, major arterials. This factor is indicative of a locational bias generated by congested travel conditions in their home area that make travel seem difficult in any direction. The factor accounting for the most variance in the Cedar Hills analysis indicates a preference for less traffic. This factor seems to indicate that Cedar Hills residents must drive into or through the CBD in many shopping situations. A preference for less travel time by the Oak Hill-Jackson respondents is also indicative of congested conditions in the sense that these people live much closer to a majority of the shopping opportunities yet feel that it takes more time to reach them. Cedar Hills respondents, on the other hand, reflect a need for routes that will lead them to more shopping opportunities closer to their home location and that would allow them to by-pass or avoid the downtown congestion indicated by the second factor.

CONCLUSIONS

The implications of these analyses for understanding the shape and extent of action spaces and the derivation of travel behavior characteristics are varied. In general, it may be concluded that the respondents in the Cedar Hills area will select routes that minimize congestion and allow for multiple-purpose trips. It would appear that multiple-purpose trips are more frequent for Cedar Hills residents because their location away from shopping opportunities forces them to evaluate the necessity of each trip. The Oak Hill-Jackson residents, on the other hand, will select routes that are major arterials and that decrease the amount of time necessary to complete their activities. The urban transportation system in Cedar Rapids has developed in such a way that north-south travel is impeded and east-west travel is facilitated. The location of the Oak Hill-Jackson area is such that residents must travel to the north to get either to the CBD or the major shopping center. Further, the Cedar Hills respondents are located at the western edge of the major east-west arterial and thus must continuously use this route to travel either to the CBD or beyond the CBD. As transportation system improvements and changes in the shopping opportunity configuration occur, one may conclude that the Cedar Hills activity space will decrease according to their preferences, whereas the activity space of the Oak Hill-Jackson residents will increase.

The empirical findings presented form the basis for several components of the conceptual framework outlined in Figure 1. Still to be completed are analyses to assess the variability in perception attributable to differences in socioeconomic attributes, length of residence, work location, and the spatial structure of friendship networks and organizational memberships. Definition of subgroups with like action spaces and travel behavior within the two sampled areas currently are being completed.

Probability matrices will be developed that are descriptive of changes in urban environmental perception with varying length of residence in the area. These matrices will be predicated on a detailed cross section of the sample, after controlling for nonhomogeneous socioeconomic characteristics. Further analyses will be designed to assess the variability in action space structure related to travel preferences and perception differences. It is envisioned that the final structure of the model will be defined by a set of simultaneous linear equations in which all components and each action space measure are included. The exact form of the equation set will be determined by the outcome of the analyses previously described. Specification of the parameters in the model will allow for considerable experimentation as to the effects of changes in the objective urban environment of travel behavior. Further, the behavioral model of urban action spaces and its extension to travel behavior will provide an improved basis for predictive models in the urban transportation planning process.

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