PERCEIVED ENVIRONMENTAL UTILITY UNDER ALTERNATIVE TRANSPORTATION SYSTEMS: A FRAMEWORK FOR ANALYSIS

PAT BURNETT

RESEARCH REPORT 35

MARCH 1976

DEPARTMENT OF TRANSPORTATION
OFFICE OF UNIVERSITY RESEARCH
WASHINGTON, D. C. 20590

COUNCIL FOR ADVANCED TRANSPORTATION STUDIES
THE UNIVERSITY OF TEXAS AT AUSTIN

RESEARCH REPORTS PUBLISHED BY
THE COUNCIL FOR ADVANCED TRANSPORTATION STUDIES

1 *An Integrated Methodology for Estimating Demand for Essential Services with an Application to Hospital Care.* Ronald Briggs, Wayne T. Enders, James Fitzsimmons, and Paul Jensen, April 1974 (DOT-TST-75-81).

2 *Transportation Impact Studies: A Review with Emphasis on Rural Areas.* Lidvard Skorpa, Richard Dodge, C. Michael Walton, and John Huddleston, October 1974 (DOT-TST-75-59).

4 *Inventory of Freight Transportation in the Southwest/Part I: Major Users of Transportation in the Dallas-Fort Worth Area.* Eugene Robinson, December 1973 (DOT-TST-75-29).

5 *Inventory of Freight Transportation in the Southwest/Part II: Motor Common Carrier Service in the Dallas-Fort Worth Area.* J. Bryan Adair and James S. Wilson, December 1973 (DOT-TST-75-30).

6 *Inventory of Freight Transportation in the Southwest/Part III: Air Freight Service in the Dallas-Fort Worth Area.* J. Bryan Adair, June 1974 (DOT-TST-75-31).

7 *Political Decision Processes, Transportation Investment and Changes in Urban Land Use: A Selective Bibliography with Particular Reference to Airports and Highways.* William D. Chipman, Harry P. Wolfe, and Pat Burnett, March 1974 (DOT-TST-75-28).

9 *Dissemination of Information to Increase Use of Austin Mass Transit: A Preliminary Study.* Gene Burd, October 1973.

10 *The University of Texas at Austin: A Campus Transportation Survey.* Sandra Rosenbloom, Jane Sentilles Greig, and Lawrence Sullivan Ross, August 1973.

11 *Carpool and Bus Matching Programs for The University of Texas at Austin.* Sandra Rosenbloom and Nancy Shelton Bauer, September 1974.

12 *A Pavement Design and Management System for Forest Service Roads: A Conceptual Study.* W. R. Hudson and Thomas G. McGarragh, July 1974.

13 *Measurement of Roadway Roughness and Motion Spectra for the Automobile Highway System.* Randall Bolding, Anthony Healey, and Ronald Stearman, December 1974.

14 *Dynamic Modeling for Automobile Acceleration Response and Ride Quality Over Rough Roadways.* Anthony Healey, Craig C. Smith, Ronald Stearman, and Edward Nathman, December 1974.

15 *Survey of Ground Transportation Patterns at the Dallas-Fort Worth Regional Airport.* William J. Dunlay, Jr., Thomas G. Caffery, Lyndon Henry, and Douglas Wiersig, August 1975.

16 *The Prediction of Passenger Riding Comfort from Acceleration Data.* Craig C. Smith, David Y. McGehee, and Anthony J. Healey, March 1976.

17 *The Transportation Problems of the Mentally Retarded.* Shane Davies and John W. Carley, December 1974.

18 *Transportation-Related Constructs of Activity Spaces of Small Town Residents.* Pat Burnett, John Betak, David Chang, Wayne Enders, and Jose Montemayor, December 1974 (DOT-TST-75-135).

19 *Marketing of Public Transportation: Method and Application.* Mark I. Alpert and Shane Davies, January 1975.

20 *The Problems of Implementing a 911 Emergency Telephone Number System in a Rural Region.* Ronald T. Matthews, February 1975.

23 *Forecast of Truckload Freight of Class I Motor Carriers of Property.* Mary Lee Gorse, March 1975 (DOT-TST-75-138).

24 *Forecast of Revenue Freight Carried by Rail in Texas to 1990.* David L. Williams, April 1975 (DOT-TST-75-139).

28 *Pupil Transportation in Texas.* Ronald Briggs, Kelly Hamby, and David Venhuizen, July 1975.

30 *Passenger Response to Random Vibration in Transportation Vehicles.* Anthony J. Healey, June 1975.

35 *Perceived Environmental Utility under Alternative Transportation Systems: A Framework for Analysis.* Pat Burnett, March 1976.

36 *Monitoring the Effects of the Dallas/Fort Worth Regional Airport. Volume I: Ground Transportation Impacts.* William J. Dunlay, Jr., Thomas G. Caffery, Lyndon Henry, Douglas W. Wiersig, and Waldo Zambrano, December 1976.

37 *Monitoring the Effects of the Dallas/Fort Worth Regional Airport. Volume II: Land Use and Travel Behavior.* Pat Burnett, David Chang, Carl Gregory, Arthur Friedman, Jose Montemayor, and Donna Prestwood, July 1976.

38 *Transportation and Community Development—A Manual for Small Communities: Level I, Volume I—Executive Summary; Volume II—The Planning Process.* Richard Dodge, John Betak, C. Michael Walton, Charles Heimsath, and John Huddleston, July 1976.

39 *An Evaluation of Promotional Tactics and Utility Measurement Methods for Public Transportation Systems.* Mark Alpert, Linda Golden, John Betak, James Story, and C. Shane Davies, March 1977.

40 *A Survey of Longitudinal Acceleration Comfort Studies in Ground Transportation Vehicles.* L. L. Hoberock, July 1976.

41 *Lateral Steering Dynamics Model for the Dallas/Fort Worth AIRTRANS.* Craig C. Smith, December 1976 (Draft Report).

42 *Guideway Sidewall Roughness and Guidewheel Spring Compressions of the Dallas/Fort Worth AIRTRANS.* William R. Murray and Craig C. Smith, August 1976 (Draft Report).

43 *A Pavement Design and Management System for Forest Service Roads: A Working Model.* Freddy L. Roberts, B. Frank McCullough, Hugh J. Williamson, William R. Wallin, February 1977.

44 *A Tandem-Queue Algorithm for Evaluation of Overall Airport Capacity.* Chang-Ho Park, April 1977 (Draft Report).

45 *Characteristics of Local Passenger Transportation in Texas.* Ronald Briggs, January 1977 (Draft Report).

PERCEIVED ENVIRONMENTAL UTILITY UNDER ALTERNATIVE TRANSPORTATION SYSTEMS: A FRAMEWORK FOR ANALYSIS

Pat Burnett

March 1976
Research Report

Document is Available to the Public
Through the National Technical Information Service
Springfield, Virginia 22151

Prepared for

Council for Advanced Transportation Studies
The University of Texas at Austin
Austin, Texas 78712

In Cooperation With

Department of Transportation
Office of University Research
Washington, D. C. 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PERCEIVED ENVIRONMENTAL UTILITY UNDER ALTERNATIVE TRANSPORTATION SYSTEMS: A FRAMEWORK FOR ANALYSIS		5. Report Date March 1976
		6. Performing Organization Code
7. Author(s) Pat Burnett		8. Performing Organization Report No. Research Report 35
9. Performing Organization Name and Address Council for Advanced Transportation Studies The University of Texas at Austin Austin, Texas		10. Work Unit No. (TRAIS) 00 3655 8
		11. Contract or Grant No. DOT OS 30093
12. Sponsoring Agency Name and Address Department of Transportation Office of University Research		13. Type of Report and Period Covered Research Report
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report is concerned with developing an analytical framework for examining residents' perception of their environmental utility under different transportation alternatives.

A 3% sample of households in Sealy, Texas, was drawn for home interviews. Information was collected on 58 variables describing household socio-economic characteristics and travel habits. Four main clusters of households were delineated. INDSCAL analysis for each of the four groups produced three basic environmental dimensions and explains the maximum amount of variance in the input data. Additional analysis shows that the individuals within their group can vary on the importance which they attach to the different dimensions. The analysis reveals that the differential cognitions and evaluations of group members lead to interest groups whose support is drawn from different socio-economic strata. Consequently, other kinds of interest groups which support or oppose transportation innovations are drawn from different socio-economic and activity groupings. The analytical framework of this report demonstrates how such interest groups are derived.

17. Key Words	18. Distribution Statement
Environmental Utility; Homogeneous Household Clusters; Principle Components Analysis; Life Cycle Phase; Income/Ethnicity; CONGRUP; INDSCAL; Environmental Dimensions.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	49	

EXECUTIVE SUMMARY

INTRODUCTION

This report is concerned with one phase of a research project entitled, "The Influence on the Rural Environment of Interurban Transportation Systems." It presents the final phase in the attempt to develop a model for predicting how different groups in small urban areas will respond to proposed or actual changes in the interurban transportation system. At the same time, the research is part of a larger effort aimed toward developing improved models of behavior within urban activity spaces in general.

PROBLEM STUDIED

The nature of the activity spaces which people use for recurrent activities (shopping, work, recreation, etc.) has received considerable attention in recent studies. At the same time, transportation planning is marked by concern about citizen involvement in the planning process. This is manifest by the studies on highways and expressway controversies.[1] It is also evident in attempts to create opportunities for citizen participation[2] and to examine the social consequences of road construction.[3] The concern with citizen involvement occurs at all scales of analysis, from the metropolitan area[4] to the small urban community.[5]

It is often noted that, in response to transportation plans, private individuals are most concerned about protection, conservation, and enhancement of their physical and social space.[6] However, little work has been done on how individuals themselves perceive the effects on their environment of new routes or other kinds of transportation innovation, such as transit services or airports. The emphasis in this report is, therefore, on developing an analytical framework for examining <u>resident's</u> perception of their environmental utility under different transportation alternatives. The analytical framework is intended for application at any scale; the usefulness of the framework, however, is demonstrated through a case study of a small urban community.

RESULTS ACHIEVED

The analytical framework developed is two-phase in design. First, a methodology is briefly outlined for defining the general attributes of the perceived environment of a class of urban residents. Then, a conceptual framework is developed for delineating homogeneous population groups within an example of such an environment and measuring each group's differential cognition and evaluation of the effects of transportation alternatives.

The first phase of the analytical framework is discussed fully in Research Report 18, available through NTIS under Report No. DOT-TST-75-135. The second phase of the research, namely, developing a conceptual framework for delineating homogeneous population groups and for measuring each group's differential cognition and the evaluation of the effects of transportation alternatives is the focus of this report.

Within a general kind of residential environment (small town, metropolitan neighborhood) we may consider a population distribution at time t. Let there be a spatially random sample of m households drawn from this population. Then we may expect some number y of households to be defined where the clusters will be homogeneous, at least in terms of (1) socio-economic status (broadly defined), stage in life cycle and ethnicity, and (2) their activity patterns. Such groups may also have distinctive cognitions and evaluations of the attributes of their perceived environment under alternative transportation systems. Given an extended set of variables describing both the socio-economic characteristics and activity patterns of the sample, y internally similar household clusters may be first defined using factor analysis and a grouping algorithm; each cluster's cognition and evaluation of its environment under alternative transport systems can then later be probed.

Given this framework, one small town, Sealy, Texas, was selected for analysis. Within the area, a three percent sample of households was drawn for home interviews to determine household socio-economic characteristics and travel habits. Interviews were carried out with one respondent in each household until 80 complete returns were compiled: two were later deleted owing to response inaccuracies. Subsequent analysis of the data and the questionnaire showed that the sample obtained was reasonably representative of the different strata of the town's population. Information was collected on 58 variables describing household socio-economic characteristics and travel habits. To find the basic dimensions which might differentiate households into clusters, a principal components analysis with varimax rotation to simple structure was performed on the 78 household by 58 variable matrix. The analysis produced 16 factors with eigenvalues greater than one; these may be treated as basic factors differentiating households. The well-known life cycle phase and income/ethnicity factors appeared with loadings on the component variables that were readily interpretable. A third socio-economic factor also appears, namely, familiarity with the town; this increases both as the year the respondent first moved into Sealy increases and as his/her total length of residence there increases. The remaining 13 basic factors were those underlying household travel behavior and were more difficult to interpret. However, all 16 factors were interpretable, so scores for each household on each factor were computed. The algorithm CONGRUP was then used to cluster households with like scores on the 16 factors. CONGRUP delineated four main clusters of households, with two major groupings of 43 and 29 members respectively, and two deviant minor groupings of four and two members. The number of component groupings was subjectively chosen, but the appearance of two major groupings conforms with Hunter's delineation of two major kinds of households in Sealy in the late sixties and early seventies.[7] Thus, the sample clusterings appear to reflect the general community makeup of the area.

Given the identification of members of various groups and their rating of environments under different transportation alternatives, we may envisage a matrix with r rows representing components of the residential environment elicited by the Personal Construct theory and Repertory Grid methodologies (as described in Research Report 18); the columns represent different possible alternative transportation strategies for an urban area. An entry in the cell of the matrix represents how much a group member perceives an urban area component to be affected by the transportation system. Thus, the matrix represents the application of rating scales to evaluate the quality of the urban environment under alternate transportation systems. The matrices for the members of the homogeneous population groups may be manipulated using the INDSCAL model to summarize the groups' cognition and evaluation of the effects of transportation alternatives on their urban environment.[8] The input to the INDSCAL model is a similarities matrix for each person of a group. The matrix for each group member has to be preprocessed so that similarities between possible pairs of transportation systems can be measured. There are various methods for doing this step. Where the ratings data have been collected from illeducated, semi-literate respondents, less refined methods of deriving similarities may be justified. In this report a simple method for preprocessing the data for INDSCAL was used: in particular, the absolute differences between each pair of systems in their average component scores over all environmental components. This step may be formally expressed using the notation in equation one. This yielded a six by six matrix of similarities for each respondent.

$$S^{i}_{jk} = \frac{\left| \sum_{t=1}^{r} X^{i}_{jt} - \sum_{t=1}^{r} X^{i}_{kt} \right|}{r} \qquad (1)$$

Given these similarities for each group of respondents, the INDSCAL model permits the calculation of the utility of each transportation system as far as the environment is concerned for each group member. This is given by

$$U_{ij} = \sum_{d=1}^{p} W_{id} \cdot x_{jd} \qquad (2)$$

where U_{ij} is the environmental utility of the jth transportation strategy for household i, W_{id} is the household's weight or importance attached to dimension d, and x_{jd} is the position of the transportation strategy on the dimension. For each group, the analysis recovered the scales comprising the group evaluation space, the position of transportation alternatives in the space, the weights of each scale for each respondent, and the environmental utilities of each transportation alternative for each respondent. For each of the four groups, three basic environmental dimensions explain the maximum amount of variance in the input data. Accordingly, these three basic factors comprise the most important dimensions on which the groups rate their environmental utilities for different transportation systems. Because the positioning of the transportation alternatives on the dimensions is different for each group, it seems clear each group has its own criteria on which transportation alternatives are evaluated.

The fact that the four groups show some communality in their dimensions suggests that the town is unified rather than divided about the advantages and disadvantages of alternative transportation systems. This is not the case, however; the INDSCAL analysis presents only composite or group viewpoints. Additional analysis shows that the individuals within the group can vary on the importance which they attach to the different dimensions. The analysis reveals that the differential cognitions and evaluations of group members lead to interest groups with supporters drawn from different socio-economic strata.

UTILIZATION OF RESULTS

While the results of the analysis are interesting in their own right, the main value is to demonstrate how the INDSCAL framework can be applied to predict political responses to transportation alternatives in an urban area. Thus, the results of this research should be of value to federal, state, and local planning agencies and to research groups interested in how groups and individuals may perceive and respond to alternative transportation systems and investments in an urban area.

CONCLUSION

This report presents a framework for analyzing how residents of urban environments perceive and evaluate transportation alternatives. A two-phase design is described. In the first phase, a procedure is developed for eliciting the components which residents conceive as comprising their environments under a transportation system. In the second phase, it was hypothesized that, in a sample population, there might be groups who would be (a) homogeneous according to a very wide range of non-traditional socio-economic and activity variables and (b) evaluate the components of their kind of environment in the same way under alternative transportation systems. This framework was successfully tested with the definition of four homogeneous groups in a case study in a small town. Finally, the INDSCAL model was employed to determine whether each homogeneous group does evaluate the components of their environment under alternative transportation systems in a distinctive way. For the kinds of homogeneous groups in the case study town it was found that they do not. Each group evaluates transportation systems along similar dimensions, but individual differences within groups are so great that some members derive maximum utility from one alternative and some from another. Thus, other kinds of interest groups which support or oppose transportation innovations are drawn from different soci-economic and activity groupings. The conceptual framework of this report demonstrates how such interest groups are derived.

REFERENCES

1. See, for example, S. Amir, "Highway Location and Public Opposition," Environment and Behavior, 4 (1972), 413-436; J. E. Burkhardt, "Community Reactions to Anticipated Freeways: Fears and Actual Effects," Highway Research Record No. 470, Highway Research Board, Washington, D.C. (1973); and G. Fellman, "Neighborhood Protest of an Urban Highway," Journal of the American Institute of Planners, 35 (1969), 118-122.

2. See, for example, D. F. Fretzsche, "Consumer Response Information - A Potential Tool for Regulatory Decisionmakers," Transportation Journal, 14 (1974), 22-26.

3. See, Kaplans, Gans and Kahn. Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvements. San Francisco: Marshall Kaplan, Gans and Kahn, 1972.

4. Sloan, A. K., Citizen Participation in Transportation Planning: The Boston Experience. Cambridge, Mass.: Ballinger, 1974.

5. Hunter, G. C., "Rural Communities and Inter-Urban Transportation Systems: A Study of the Stages of Inter-Action," Master's Thesis, Department of Architecture, The University of Texas at Austin, 1974.

6. Hinman, J., "Controversial Facility-Complex Programs: Coalitions, Side-Payments, Social Decisions," Discussion Paper No. 8, Research on Conflict in Locational Decisions, Department of Regional Science, University of Pennsylvania, 1970.

7. Hunter, op. cit.

8. Shepard, R. N., A. K. Romney, and S. B. Nerlove (Eds.). Multidimensional Scaling, Vol. I: Theory. New York: Seminal Press, 1972.

ACKNOWLEDGEMENTS

The assistance of J. F. Betak and J. Montemayor is gratefully acknowledged. The cooperation of the many people of Sealy, Texas, is most sincerely and warmly appreciated.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Transportation planning is marked by a concern about citizen involvement in the process. This is manifested by the plethora of studies on highway and expressway controversies.[1] It is also evident in attempts to create opportunities for citizen participation[2] and to examine the social consequences of road construction.[3] The concern with citizen involvement occurs at all scales of analysis, from the metropolitan area[4] to the small urban community.[5]

---

1 Amir, S., "Highway Location and Public Opposition." Environment and Behavior, 4 (1972), 413-436; J. E. Burkhardt, "Community Reactions to Anticipated Freeways: Fears and Actual Effects," Highway Research Record, No. 470 (1973), 22-31; G. Fellman, "Neighborhood Protest of an Urban Highway," Journal of the American Institute of Planners, 35 (1969), 118-122; A. Gonen, "The Spadina Expressway Conflict in Toronto: Decision and Opposition," Discussed Paper No. 5, Research on Conflict in Locational Decisions, Department of Regional Science, University of Pennsylvania, 1970; A. J. Mumphrey, "The New Orleans Riverfront Expressway Controversy: An Analytical Account," Discussion Paper No. 1, Research on Conflict in Locational Decisions, Department of Regional Science, University of Pennsylvania, 1970; A. J. Mumphrey, "A Monte Carlo Simulation of Highway Planning and Citizen Opposition: The Pennsylvania Planning Opposition Simulation," Discussion Paper No. 9, Research on Conflict in Locational Decisions, Department of Regional Science, University of Pennsylvania, 1971; J. H. Schermer, "Interest Group Impact Assessment in Transportation Planning." Traffic Quarterly, 39 (1975), 29-49; J. E. Seley, "Development of a Sophisticated Opposition: The Lower Manhattan Expressway Issue," Discussion Paper No. 2, Research on Conflict in Locational Decisions, Department of Regional Science. University of Pennsylvania, 1970.

2 Fretzsche, D. J., "Consumer Response Information - A Potential Tool for Regulatory Decisionmakers," Transportation Journal, 14 (1974), 22-26; M. L. Manheim, et al. Community Values in Highway Location and Design: A Procedural Guide: Final Report. Cambridge, Mass.: The M.I.T. Urban Systems Laboratory, 1971; C. Ryan, et al., "A Review of the Public Hearing Process as a Means of Obtaining Citizens' Views and Values," Highway Research Record, No. 467 (1974), 24-25.

3 Kaplan, Gans and Kahn, Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvements. San Francisco: Marshall Kaplan, Gans and Kahn, 1972; D. Nasatir, The Social Consequences of BARTS Environmental Impact: Some Preliminary Considerations and Hypotheses. Berkeley, California: University of California at Berkeley, 1974.

4 Sloan, A. K. Citizen Participation in Transportation Planning: The Boston Experience. Cambridge, Mass: Ballinger, 1974.

5 Hunter, G. C., "Rural Communities and Inter-Urban Transportation Systems: A Study of the Stages of Interaction," Master's Thesis, Department of Architecture, The University of Texas at Austin, 1974.

It has often been noted that, in response to transportation plans, private individuals are most concerned about the protection, conservation, and enhancement of their physical and social space.[6] However, little work has been done on how individuals themselves perceive the effects on their environment of new routes or other kinds of transportation innovation, such as transit services or airports. The emphasis in this report is therefore on developing an analytical framework for examining residents' perceptions of their environmental utility under different transportation alternatives. The analytical framework is intended for application at any scale; the usefulness of the framework, however, is demonstrated through a case study of a small urban community.

The analytical framework is two-phase in design. First, a methodology is briefly outlined for defining the general attributes of the perceived environment of a class of urban residents, for example, small town residents or residents in neighborhoods within a city. Then a conceptual framework is developed for delineating homogeneous population groups within an example of such an environment and for measuring each group's differential cognition and evaluation of the effects of transportation alternatives.

---

6 Himman, J., "Controversial Facility-Complex Programs: Coalitions, Side-Payments, Social Decisions," Discussion Paper No. 8, Research on Conflict in Locational Decisions, Department of Regional Science, University of Pennsylvania, 1970.

PART I

DEFINING THE GENERAL ATTRIBUTES OF THE PERCEIVED ENVIRONMENT

Proposed alterations in transportation affect the behavior of residents in the vicinity. Conceptually, each person can be viewed as having an individual activity space containing a unique set of n elements or places to which he/she attaches some utility.[7] Following Harrison and Sarre, each element i can be viewed as defined by a number of constructs, m_i $(i = 1, . . ., n)$, that is, meanings which the individual ascribes to the place.[8] Constructs are subjectively percieved characteristics of all the places a person uses or values in his/her activity space under a transportation system. However, constructs may also be conceived as bipolar scales (e.g., near, far) describing all the elements which make up the percieved environment for the individual.

Although each person will have a unique set of elements and constructs comprising his/her own activity space, it is plausible to argue that similarities will exist in the systems of individuals in similar locations and with similar backgrounds - for example, residents of small towns or residents within metropolitan neighborhoods. Thus, to study the effects of transportation proposals on perceived environments, the constructs defining places in the environment must first be elicited.

For a class of urban residents of interest, Kelly's Personal Construct Theory and related procedures may be used, together with their extensions by Bannister; Bannister and Mair; Bonnarius; Epting,

---

[7] Brown, L. and E. G. Moore, "The Intra-Urban Migration Process: A Perspective," Geografiska Annaler, 52, Series B. (1970), 1-13; F. E. Horton and D. R. Reynolds, "The Investigation of Individual Action Spaces: A Progress Report." Proceedings of the Association of American Geographers, 1 (1969), 70-74.

[8] Harrison, J. and P. Sarre, "Personal Construct Theory in the Measurement of Environmental Images: Problems and Methods," Environment and Behavior, 3 (1971), 351-374.

Suchman and Nickerson; and Slater.[9] The procedures employ a small sample of the population of interest but provide a rigorous method whereby the constructs of places in activity spaces can be suggested by residents rather than researchers.

To illustrate the use of the theory and the procedure for one general class of urban residents, we can take the elicitation of the constructs which define places for small town residents. (The population sizes of the towns range from 2,000 to 20,000). Since the details of this survey have been described elsewhere only a brief outline is required here.[10] First, a sample of small town residents was drawn: in this case 31 freshmen University students were selected to demonstrate the procedures involved. Each respondent listed all the places he/she used or valued about his/her home town, that is, all the elements of his/her activity space. Examples of listed elements are home, church, and corner store. Although each respondent listed a different set of places, there is no reason to believe that overall the lists did not provide a representative sample of places used by small town residents in general.

---

9 Kelly, G. A. The Psychology of Personal Constructs. New York: W. W. Norton, 1955; D. Bannister, "Personal Construct Theory: A Summary and Experimental Paradigm," Acta Psychologica, 20 (1962), 104-120; D. Bannister and J. M. M. Mair, The Evaluation of Personal Constructs. London: Academic Press, 1963; J. C. J. Bonnarius, "Research in the Personal Construct Theory of George A. Kelly: Role Construct Repertory Test and Basic Theory," in B. A. Mahr (Ed.) Progress in Experimental Personality Research. New York: Academic Press, 1965, pp. 1-46; F. R. Epting, D. I. Suchman, and G. J. Nickerson, "An Evaluation of Elicitation Procedures for Personal Constructs," British Journal of Psychology, 62 (1971), 513-517; P. Slater, "Theory and Techniques of the Repertory Grid," British Journal of Psychiatry, 115 (1969), 1287-1296; P. Slater, Notes on INGRID 72. London: Institute of Psychiatry.

10 Burnett, K. P., et al. Transportation-Related Constructs of Activity Spaces of Small Town Residents, Research Report 18, Council for Advanced Transportation Studies, The University of Texas at Austin, 1974.

Next the triadic comparison method was utilized to elicit all the constructs defining all the elements on each respondent's list. Sets of three elements on the list were presented at random to each respondent; each time two elements considered similar were placed together and the third contrasting element was placed apart. The reason for the similarity and contrast between places was asked; this yielded descriptions such as "secure" and "insecure," that is, the contrasting poles of the construct or characteristic defining the triad of places. Triads were presented to every respondent until no new constructs were elicited. Thus, overall, the cognitive meanings ascribed to the range of places listed within small towns were elicited from all the respondents.

The triadic comparison procedure obviously can be yield a very large number of constructs or environmental descriptions even with a small sample. Slater's algorithm INGRID was developed to present such information in a more parsimonious form.[11] To utilize the algorithm, repertory grids must be constructed for each respondent: in our sample case, these took the form of the matrix outlined in Figure 1, where rows represent the preferred poles of the respondent's constructs, columns represent the elements of his or her activity space, and the entry in cell ij is the rating of how much of the preferred characteristic each element possessed (the ratings ranged from 1, most or top-scoring, to 7, least). The INGRID algorithm is a modified principal components analysis of each respondent's grid, such that clusters of preferred construct poles, or attributes, result. This leads to the extraction of the essential definitive substance of respondents' perceptions of their environment--for example, 38 constructs elicited from three subjects were reduced to only eight environmental components in the case study. In addition, 17 components occurred more than once for different respondents. These are listed in Table 1 and indicate communalities in the perception of small town environments. Although there are obvious problems of small sample size and aggregation, these 17 components were taken as

---

[11] Slater, Notes . . ., op cit.

Preferred Pole of Construct	Element (Place) in Town																	
	Home 1	School 2	Church 3	Weekend Shop 4	Supermarket 5	Hangout 6	.	.	.	.	.	.	.	.	.	Coffee House 22	Coke Street 23	Bakery 24
1 Affectionate	1	4	3	7	4	1	.	.	.	.	.	.	.	.	.	3	7	7
2 Calm	5	5	6	4	6	3	.	.	.	.	.	.	.	.	.	2	6	7
3 Private	4	5	4	4	7	2	.	.	.	.	.	.	.	.	.	2	5	7
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13 Exciting	4	2	6	2	1	1	.	.	.	.	.	.	.	.	.	2	6	6
14 Educational	3	2	6	2	1	1	.	.	.	.	.	.	.	.	.	3	6	7

Figure 1. Example of a repertory grid.

bundles of constructs defining the perceived environment of small town residents. Components like those in Table 1 can readily be seen to provide adjectives which can be used in semantic differentials or other forms to rate the environment.

The foregoing has illustrated an analytical framework for defining a general kind of residential environment as it is perceived by its inhabitants. We now turn to a methodology for delineating population groups within an example of such a residential environment and for measuring each group's differential cognition and evaluation of the effects of transportation alternatives.

PART II

THE DELINEATION OF HOMOGENEOUS POPULATION GROUPS

Conceptualization

Within a general kind of residential environment (small towns, metropolitan neighborhoods) we may consider a population distribution at time t. Let there be a spatially random sample of m households drawn from this population. Then we may expect some number y of household clusters to be defined where the clusters will be homogeneous, at least in terms of (1) socio-economic status (broadly defined), stage in life cycle, and ethnicity and (2) their activity patterns. Such groups may also have distinctive cognitions and evaluations of the attributes of their perceived environment under alternative transportation systems. These expectations follow from Burnett and the well-known work by Berry and others on urban factorial ecology.[12] It also draws on work by Brail and Chapin which demonstrates correlation of activity patterns with the demographic characteristics of urban residents.[13] Finally, there is some evidence that environmental cognition and evaluation varies with socio-economic status.[14]

---

[12] Burnett, K. P., "Decision Processes and Innovations: A Transportation Example," Economic Geography, 51 (1975), 278-289 B. J. L. Berry (Ed.) Comparative Factorial Ecology (Special Edition) Economic Geography, 47, Supplement (1971); B. J. L. Berry and P. Rees, "The Factorial Ecology of Calcutta," American Journal of Sociology (1969), 445-491; L. S. Bourne and R. A. Murdie, "Interrelationships of Social and Physical Space in the City: A Multivariate Analysis of Metropolitan Toronto," Canadian Geographer, 16 (1972), 211-229.

[13] Brail, R. K. and F. S. Chapin, "Activity Patterns of Urban Residents," Environment and Behavior, 5 (1973), 163-190.

[14] Horton and Reynolds, "The Investigation . . .," op cit.; R. J. Johnston, "Activity Spaces and Residential Preferences: Some Tests of the Hypotheses of Sectoral Maps," Economic Geography, 48 (1972), 199-211.

TABLE 1.

COMPONENTS DEFINING THE PERCEIVED ENVIRONMENT

FOR SMALL TOWN RESIDENTS

1. Preservation of family ties and friendships
2. Enjoyable outdoor recreation with others
3. Personal freedom
4. Country-western activities
5. Access to sophisticated entertainment
6. Restraints on behavior because everyone knows you
7. Challenge, excitement, adventure
8. Informal relationships
9. Access to luxuries of life
10. Pressure to achieve
11. Peace, tranquillity
12. Relaxation
13. Routine activities
14. Attractive rural surroundings
15. Intellectual stimulation
16. Accessibility to people and places
17. Personal privacy

Given an extended set of variables describing both the socio-economic characteristics and activity patterns of the sample, y internally similar household clusters may first be defined using factor analysis and a grouping algorithm; each cluster's cognition and evaluation of its environment under alternative transport systems can then later be probed. The initial formation of household clusters may first be demonstrated for a case study situation.

The Case Study Population Groups

Given that the general perceived environment of small towns was described above, one small town, Sealy, Texas, was selected for analysis. This town had a population of 2685 in the 1970 Census. Within the area, a 3 per cent sample of households was drawn for home interviews to determine household socio-economic characteristics and travel habits. Since there was no listing of households by address to provide a sampling frame, block fronts on a street map were numbered and then selected using a table of random numbers. As many households on a selected blockfront were contacted as possible, producing a spatially random clustered sample. One callback per household was used. Interviews were carried out with one respondent in each household during August, 1974, until 80 completed returns were compiled: two were later deleted owing to response inaccuracies. A map of the sampled households is shown in Figure 2. Subsequent analysis of the data in the questionnaires showed that the sample obtained in this way was reasonably representative of different strata in the town's population (Table 2).

Information was collected on 58 variables describing household socio-economic characteristics and travel habits. These variables comprise the S and A sets of Table 3. To find the basic dimensions which might differentiate households into clusters, a principal components analysis with varimax rotation to simple structure was performed on the 78 household by 58 variable matrix.[15] Since some

[15] The program used for the factor analysis was Veldman's "Factor," a special program written for the CDC 6600 system at the University of Texas at Austin. (Donald J. Veldman, VSTAT User Manual. University of Texas at Austin, 1974, p. 28).

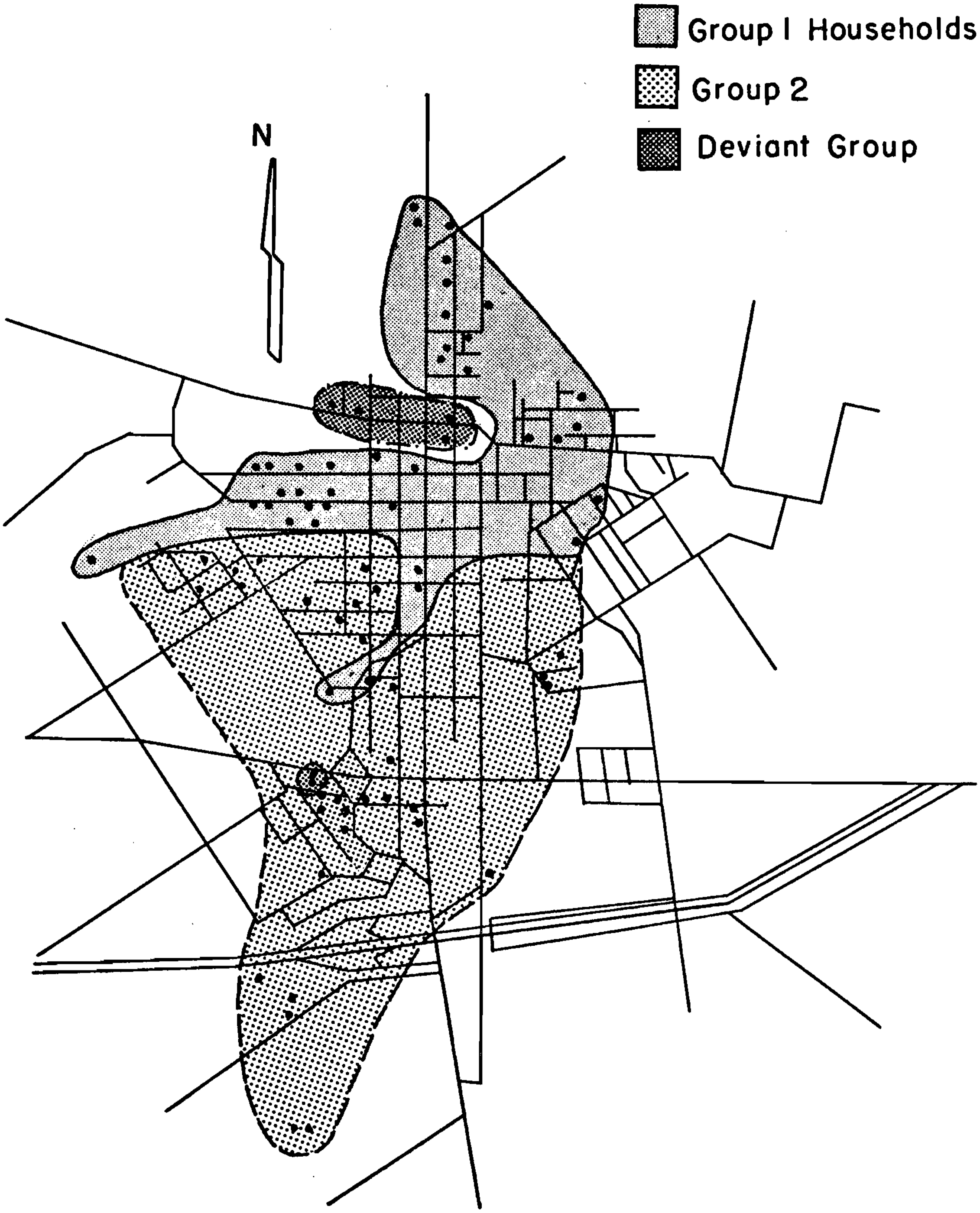


Figure 2. Locations and kinds of households in Sealy, Texas.

TABLE 2. PROPORTION OF 1970 POPULATION AND 1974 SAMPLE IN DIFFERENT STRATA.

	Percent Foreign Born	Females 16 Years & Older-Percent in Labor Force	Employed Persons-Percent in Manu-facturing	Percent Negro & Other Races	Percent 18-64 Years	Percent 65 Years & Older	Males Over 14 Years-Percent Married	Females Over 14 Years-Percent Married	Persons 18 Years & Older-Percent Male
Population (1970)	3.8	23	4	9	68	25	30	42	40
Sample	3.7	21	6	7	63	26	32	38	37

Source: General Social and Economic characteristics of Sealy, Texas PC(1) - C45, L.S. Department of Commerce, Social and Economics Statistics Administration, Bureau of the Census, issued April 1972, Table 16.

of the variables were categorical (for example, religion of respondent), they were treated as dummies, with each category assigned a number.

The analysis produced sixteen factors with eigenvalues greater than one; these may be treated as basic factors differentiating households (Table 4).[16] The well-known life cycle phase and income/ethnicity factors appeared with loadings on the component variables that were readily interpretable. For example, as the life cycle phase factor increases, number of residents in household decline and age of respondent and life stage of household increase. A third socio-economic factor also appears, namely, familiarity with the town; this increases both as the year the respondent first moved into Sealy increases and as his/her total length of residence there increases.

The remaining 13 basic factors were those underlying household travel behavior and were more difficult to interpret. Some examples may be taken, however. Indoor recreation (Factor 7, Table 4) increases as the place of recreation changes and as the time taken to get there decreases. However, indoor recreation also increases as frequency of visit decreases, perhaps indicating that as travel time decreases, more time is spent at the recreation center and fewer trips are made. In contrast, for speciality goods like car purchasing (Factor 13, Table 4), as the time to the place of purchase increases, so does the frequency of the trip. This may well be because larger towns further away from Sealy offer a better array of automobiles and other speciality goods from which to shop. A final example of a less easily interpretable factor may be taken, that of opportunity for private indoor activities (Factor 15, Table 4). This opportunity increases as the frequency of using a restaurant decreases, and as the place used for a library changes. However, it also increases as the time to a restaurant decreases. This apparent anomoly may be explained by the fact that restaurants far from Sealy are preferred, compared with the limited facilities available in Sealy itself.

---

[16] Rummel, R. J., "Understanding Factor Analysis," Journal of Conflict Resolution, 40 (1967), 440-480.

TABLE 3. VARIABLES USED IN THE FACTOR ANALYSIS
3A S (SOCIO-ECONOMIC) SET

1	Year respondent first moved to Sealy
2	Total length of residence in Sealy of respondent
3	Number of persons permanently resident in household
4*	Occupation of respondent
5	Years of schooling of respondent
6	Number of cars in household
7*	Country or origin of respondent
8	Number of rooms in dwelling
9	Age of respondent
10*	Religion of respondent
11	Total weekly income of household ($ US)
12	Number of bathrooms in dwelling
13*	Sex of respondent
14*	Racial descent of respondent
15*	Place of employment of respondent
16**	Life stage of household

* Dummy variable

** Categories based on the ages of the household head and spouse, and ages of children, if any.

TABLE 3. VARIABLES USED IN THE FACTOR ANALYSIS (cont.)

3B A (ACTIVITY) SET

17*	Place usually shopped for groceries
18	Frequency of groceries shopping
19	Time to place for groceries
20*	Place usually shopped for clothing
21	Frequency of clothing shopping
22	Time to place for clothing
23*	Place used to shop for a car
24	Frequency of shopping for a car
25	Time to place for a car
26*	Place used for banking
27	Frequency of banking
28	Time to place for banking
29*	Place used for hairdressing
30	Frequency of hairdressing
31	Time to place for hairdressing
32*	Place used for doctor
33	Frequency of doctor's visits
34	Time to place for doctor
35*	Place used for indoor recreation
36	Frequency of indoor recreation
37	Time to place for indoor recreation
38*	Place usually used to see close relatives
39	Frequency of visiting relatives
40	Time to relatives' place

(cont.)

TABLE 3. VARIABLES USED IN THE FACTOR ANALYSIS (cont.)

3B A (ACTIVITY) SET

41*	Place usually used for a movie
42	Frequency of seeing movie
43	Time to place of movie
44*	Place usually used for a restaurant
45	Frequency of using restaurant
46	Time to restaurant
47*	Place usually used as library
48	Frequency of use of library
49	Time to library
50*	Place usually used to see friends
51	Frequency of visiting friends
52	Time to place of friends
53*	Place used to take visitors out
54	Frequency of taking visitors out
55	Time to place to take visitors out
56*	Place usually used for distant relatives
57	Frequency of visiting distant relatives
58	Time to place of distant relatives

TABLE 4. FACTORS WITH EIGENVALUES GREATER THAN ONE.

Factor	% Var.	Variables and loadings (in parenthesis)
1. Life cycle phase	4.85	3(-.67); 9(.64); 16(.74)
2. Ethnicity/Income	5.27	8(.74); 12(.80); 14(.56); 29(.57); 30(.52)
3. Familiarity with town	4.34	1(.91); 2(.90)
4. Non-family socializing	5.77	40(.72); 41(.76)
5. Banking opportunities	5.45	27(-.87); 28(-.85)
6. Occupation trips	4.39	4(-.78); 15(-.70); 30(-.51); 31(-.55)
7. Indoor recreation	4.41	35(-.60); 36(-.90); 37(-.89)
8. Infrequent types of trips	6.73	23(.55); 48(.60); 54(.50); 57(.62); 58(.77)
9. Socializing with friends	5.28	50(-.70); 51(-.85); 52(-.83)
10. Opportunities for doctor's visits	2.77	32(.78)
11. Grocery shopping opportunities	3.74	18(-.75); 19(-.70)
12. Choice of quality professional care	3.25	5(.53); 32(-.57)
13. Car purchase opportunities	2.98	24(.68); 25(.73)
14. Intellectual companionship	3.18	49(.72); 50(.74)
15. Opportunity for private indoor activities	5.90	45(.-.81); 56(-.84); 47(-.74)
16. Opportunities for clothing purchases	2.70	22(.74)

All 16 factors are interpretable as exemplified, so scores for each household on each factor were computed. The algorithm CONGRUP was then used to cluster households with like scores on the 16 factors.[17] As well as using constraints on the similarity of factor scores in forming household clusters, CONGRUP also employs a well-known 'contiguity' constraint: that is, households have to be contiguous to each other to be included in a group. Accordingly, CONGRUP delineated four main clusters of neighboring households, with two major groupings of 43 and 29 members respectively, and two deviant minor groupings of four and two members (Figure 2). The number of component groupings was subjectively chosen, but the appearance of two major groupings conforms with Hunter's delineation of two major kinds of households in Sealy in the late 60's and early 70's.[18] Thus, the sample clusterings appear to reflect the general community makeup of the area. To the north is a zone of older housing with residents of older age and lower socio-economic status; this area also contains the ethnic ghetto of the town. To the south and the west, the residents are more youthful, have lived in Sealy for a less lengthy period, and are generally of higher socio-economic status (Figure 2). Given a manner in which homogeneous groupings of the population can be defined, we may now turn our attention to a method of analysis of their cognition and evaluation of environmental attributes under alternative transport systems.

---

[17] The program CONGRUP was adapted to the CDC 6600 system at the University of Texas at Austin by Dr. R. Briggs, Department of Geography. It is based on Ward (1963).

[18] Hunter "Rural Communities . . .," op cit.

PART III

THE DIFFERENTIAL COGNITION AND EVALUATION OF THE ENVIRONMENT UNDER ALTERNATIVE TRANSPORT SYSTEMS

Conceptualization

The first part of the report delineates the components (bundles of constructs) which define the residential environment for a class of urban dwellers. Different population groups may perceive their environment as desirably or adversely affected by alterations in the transportation systems of an urban area. For example, one group could perceive the attribute of small towns "preservation of family ties and relationships" (Table 1) as severely disrupted by an interstate highway.

To conceive how members of various groups rate their environments under different transportation alternatives, we may envisage a matrix of the kind shown in Figure 3. In this figure, the r rows represent components of the residential environment elicited by the Personal Construct Theory and Repertory Grid methodologies; the columns represent different possible alternative transportation strategies for an urban area. An entry in the cell of the matrix represents how much a group member perceives an urban area component to be affected by the transportation system, ranging from 1, extremely favorably, to 7, extremely unfavorably. The matrix thus represents the application of 7 point rating scales to evaluate the quality of the urban environment under alternative transportation systems. If it is desired to investigate the effects of environmental components not elicited from the residents themselves (for example, town growth in the case of the small town residents of Table 1), these components can be added as extra rows. The stress in this report, however, is on evaluating the urban environment from the resident's point of view. Consequently, the rows of the matrix of Figure 3 are viewed as composed entirely, or mostly, of residents' elicited perceptions of urban area attributes.

The matrices for the members of a homogeneous population group may be manipulated using the INDSCAL model to summarize the group's

Transportation System Alternative

Environmental Component	Before Freeway 1	After Freeway 2	With Dial-a-bus 3	With Train 4
1. Accessibility to friends	7	1	4	4
2. Peace, tranquility	1	7	3	5
3. Preservation of friendship	6	3	4	4
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
r Personal freedom	7	2	3	3

Figure 3. Group member's evaluation of the effects of alternative transportation strategies on his/her residential environment.

cognition and evaluation of the effects of transportation alternatives on their urban environment.[19] The input to the INDSCAL model is a similarities matrix for each person of a group. Accordingly, a matrix like Figure 3 for each group member has to be preprocessed so that similarities between each possible pair of transportation systems can be measured. There are various methods of doing this, for example, by using the program DISTAN after ratings across the n stimuli (transportation systems) have been standardized to zero mean and unit standard deviation.[20] Or, alternatively, following Nicholaidis, the scores for a transportation system can be conceived as represented by a vector [21]

$$X^i_{jt} = (X_{j1}, X_{j2}, \ldots, X_{jr})$$

in a space of the r environmental attributes of Figure 3, where i = a group member, j = the transportation system, and t is an environmental component. The perceived similarity of any pair of transportation systems by a group member is then given by

$$S^i_{jk} = \sum_{t=1}^{r} \left[X^i_{jt} - X^i_{kt}\right]^2 \quad j, k = 1 \ldots n \text{ (number of transportation systems).} \qquad (1)$$

Where the ratings data have been collected from illeducated, semi-illiterate respondents, less refined methods of deriving similarities may be justified: for example, the use of the absolute differences between each pair of systems in their total or average scores over all environmental components. Formally, using the same notation as above, this becomes

$$S^i_{jk} = \left| \left(\sum_{t=1}^{r} X^i_{jt}\right) - \left(\sum_{t=1}^{r} X^i_{kt}\right) \right|, \; j, k=1 \ldots n \qquad (2)$$

in the former case and

---

[19] Shepard, R. N., A. K. Romney and S. B. Nerlove (Eds.) Multidimensional Scaling. Volume 1: Theory. New York: Seminar Press, 1972.

[20] Green, P. E. and V. R. Rao. Applied Multidimensional Scaling. New York: Holt, Rinehart and Winston, 1972.

[21] Nicholaidis, G. C., "Quantification of the Comfort Variable," Transportation Research, 9 (1975), 55-66.

$$S^i_{jk} = \frac{\left| \sum_{t=1}^{r} X^i_{jt} - \sum_{t=1}^{r} X^i_{kt} \right|}{r} \qquad (3)$$

in the latter case.

The similarities between transportation systems have been calculated according to the systems' evaluated effects on a relatively large number of components of the urban residential environment. The application of INDSCAL enables the identification of the few most important latent, subjective scales which 'lie behind' each group member's evaluation of the effects of the transportation systems on their environment. Following Carroll, assume that there exists a set of a few important but latent environmental scales which generate group members' similarities judgements.[22] Let there be p such scales. Assume further that all the latent scales are common to the households in a homogeneous group. Then the p scales represent the most important dimensions of the group's evaluation space, and x_{jd} ($j = 1 \ldots n$, $d = 1 \ldots p$) represents the value of each of the transportation alternatives on each of the important environmental dimensions in the group evaluation space.

Assuming that the latent scales are common to all the households in a cluster seems a very strong homogeneity assumption. However, under the INDSCAL model, any household, i, has a unique set of weights $W_i = (W_{i1}, W_{i2}, W_{i3}, \ldots, W_{ip})$ which it attaches to each of the p scales. Theoretically, any of the W_i can equal 0 and thus some group members can attach no importance to some environmental dimensions. However, it is anticipated that within a homeogeneous cluster of households, none of the weights will equal zero (that is, households will share a common set of important dimensions to evaluate transportation alternatives). Nonetheless, there may be inter-household differences in weights, reflecting realistic inter-household differences in the importance attached to the basic dimensions used to evaluate the environment.

---

[22] Carroll, J. D., "Individual Differences and Multidimensional Scaling", in R. M. Shepard, A. K. Romney, and S. B. Nerlove (Eds.) Multidimensional . . ., op cit., pp. 105-155.

The INDSCAL model also permits the calculation of the utility of each transportation system as far as the environment is concerned for each group member. This is given by

$$U_{ij} = \sum_{d=1}^{p} W_{id} \cdot x_{jd} \quad (4)$$

where U_{ij} is the environmental utility of the j^{th} transportation strategy for household i, W_{id} is the household's weight or importance attached to dimension d, and x_{jd} is the position of the transportation strategy on the dimension (this is similar to Nicholaidis' derivation of utilities for modal attributes). It will be of concern to note whether all households in a group find that the same transportation system alternative maximizes their environmental utility, that is, whether they form an environmental interest group.

Many other sources contain further details of the INDSCAL model.[23] However, sufficient of its details have been presented to provide the conceptual framework for the analysis of this report. The manner in which the INDSCAL model is actually fit to (dis)similarities matrices, like those of each household in a cluster here, is also presented in the noted sources. It remains to demonstrate how the environmental effects of different transportation alternatives could be measured.

The Case Study: Respondents' Environmental Cognition and Evaluation

In 1974 the residents of the case study town either had experience of, or were exposed to, debate about six alternative transportation systems. They had experience of a period prior to the opening of an interstate highway in 1968 and after it; there were also discussions of the addition of an AMTRAK train stop in the town, the upgrading or the downgrading of country bus services in terms of scheduling and destination, and the addition of a local intrastate airstrip.[24]

---

23. Ibid., Green and Rao, Applied . . ., op cit., Nicholaidis, "Quantification . . .," op cit.

24. Hunter, "Rural Communities . . .", op cit.

Accordingly, every member of the four groups in the town rated the 17 elicited components of their residential environment (Table 1) under each transportation alternative, from 1, most advantageously affected, to 7, most disadvantageously affected. This produced a matrix for each sampled household of the kind shown in Figure 4. In addition, each respondent similarly rated the effects of the transportation facilities on six other components of their community. These components were suggested as important by Hunter after perusal of the local town newspaper and included[25]

(a) the attractiveness of the town to industry,

(b) the attractiveness of the town to retailing and office use,

(c) the respondent's household income,

(d) the community income,

(e) neighborhood land values, and

(f) population growth.

This produced a 23 x 6 matrix of ratings for each member of each of the four household groups in the town. It should be noted that each respondent was asked to use all the numbers between 1 and 7 where possible in rating, but that most of the small town residents were ill-educated and had considerable trouble filling out a matrix of the type shown in Figure 4.

The simplest method of preprocessing the data for INDSCAL analysis was therefore used. For each member of each homogeneous population group a similarities matrix was prepared. The similarities measure used was the difference between the average component scores for each pair of transportation systems (Equation 3). This yielded a six by six matrix of similarities for each respondent, of which an example is shown in Table 5.

The similarities matrix for each group of respondents in turn was next subjected to INDSCAL analysis. For each group, the analysis recovered the scales comprising the group evaluation space, the position of transportation alternatives in the space, the weights of each scale for each respondent, and the environmental utilities for each

---

[25] Ibid.

Environmental Component	Before Interstate Highway	After Interstate Highway	Present Facilities Plus Train Stop	Improved Bus Services	No Bus Services	Local Intrastate Airstrip
	Transportation System Alternative					
	1	2	3	4	5	6
1. Preservation of family ties	1	6	4	4	6	2
2. Outdoor recreation	3	1	3	3	5	2
3. Personal freedom	7	3	3	3	6	2
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
17. Personal privacy	7	2	3	3	6	1

Figure 4. Group member's evaluation of the effects of alternative transportation strategies on his/her residential environment in Sealy.

TABLE 5. SIMILARITIES MATRIX FOR RESPONDENT 1, GROUP 1.

Transportation System	1	2	3	4	5	6
1	.00	.37	.50	.40	.83	.53
2	.37	.00	.13	.03	.47	.17
3	.50	.13	.00	.10	.33	.03
4	.40	.03	.10	.00	.43	.13
5	.83	.47	.33	.43	.00	.30
6	.53	.17	.03	.13	.30	.00

transportation alternative for each respondent.

For each of the four groups three basic environmental dimensions explained the maximum amount of variance in the input data (Table 6). Accordingly, these three basic factors comprised the most important dimensions on which the groups rated their environment under different transportation systems. Because the positioning of the transportation alternatives on the dimensions is different for each group, it seems clear each group has its own criteria on which it evaluates transportation alternatives. The different positionings of the alternatives with respect to each dimension are shown in Figures 5a through 8b.

The average scores for each group of all the systems on each of the original 23 components were used to name the scales (dimensions) (Table 7). For Group 1, environmental Dimension 1 (Figure 5a) ranges from a high associated with improved mass transit and freeway services to a low associated with the absence of both, particularly mass transit. This correlates with favorable average scores being given by the group to facilities which promote access to outdoor recreation, to sophisticated amenities, and to people and places which give personal freedom as against small town intimacy (Table 7, Column 1). The accent on bus services on this dimension makes it plausible to assume that it is an access to personal freedom and relaxation dimension. Dimension 2, on the other hand, places negative weights in high access systems (bus, freeway, Amtrak, airstrip) and positive ones on an environment with little or no mass or freeway transportation. This is labeled as a rural community dimension; systems scored favorably on average where they preserved family ties while maintaining population growth (Table 7, Column 1). The third dimension appears to be an anti-economic growth dimension; the three transportation systems promoting growth score low, while the three which do not or are dubious (the airstrip) score high. There is evidence of mixed feelings in the town towards systems promoting growth. Although many persons scored them unfavorably, many also scored them favorably, so that overall the antigrowth dimension appears (Table 7, Column 1).

TABLE 6. VARIANCE EXPLAINED BY DIMENSIONS FOR CASE STUDY POPULATION GROUPS.

No. Dimensions	% Variance Explained for Group			
	1	2	3	4
1	45.62	46.75	52.86	55.26
2	69.32	63.32	70.32	73.33
3	78.51	73.92	75.16	78.41
4	68.24	67.56	66.51	62.37

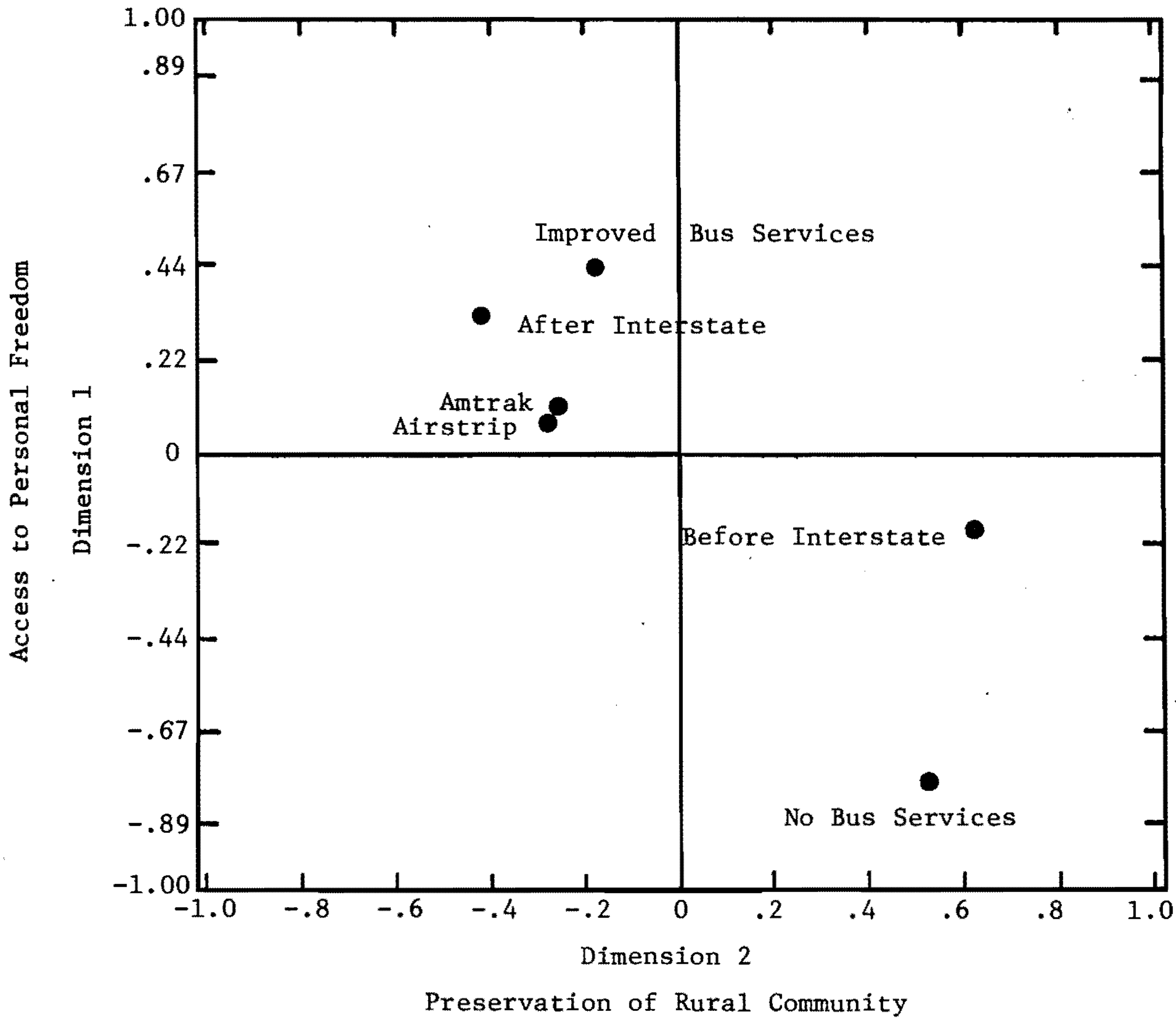


Figure 5a. INDSCAL plot of transportation alternatives-Group 1, Dimensions 1 and 2.

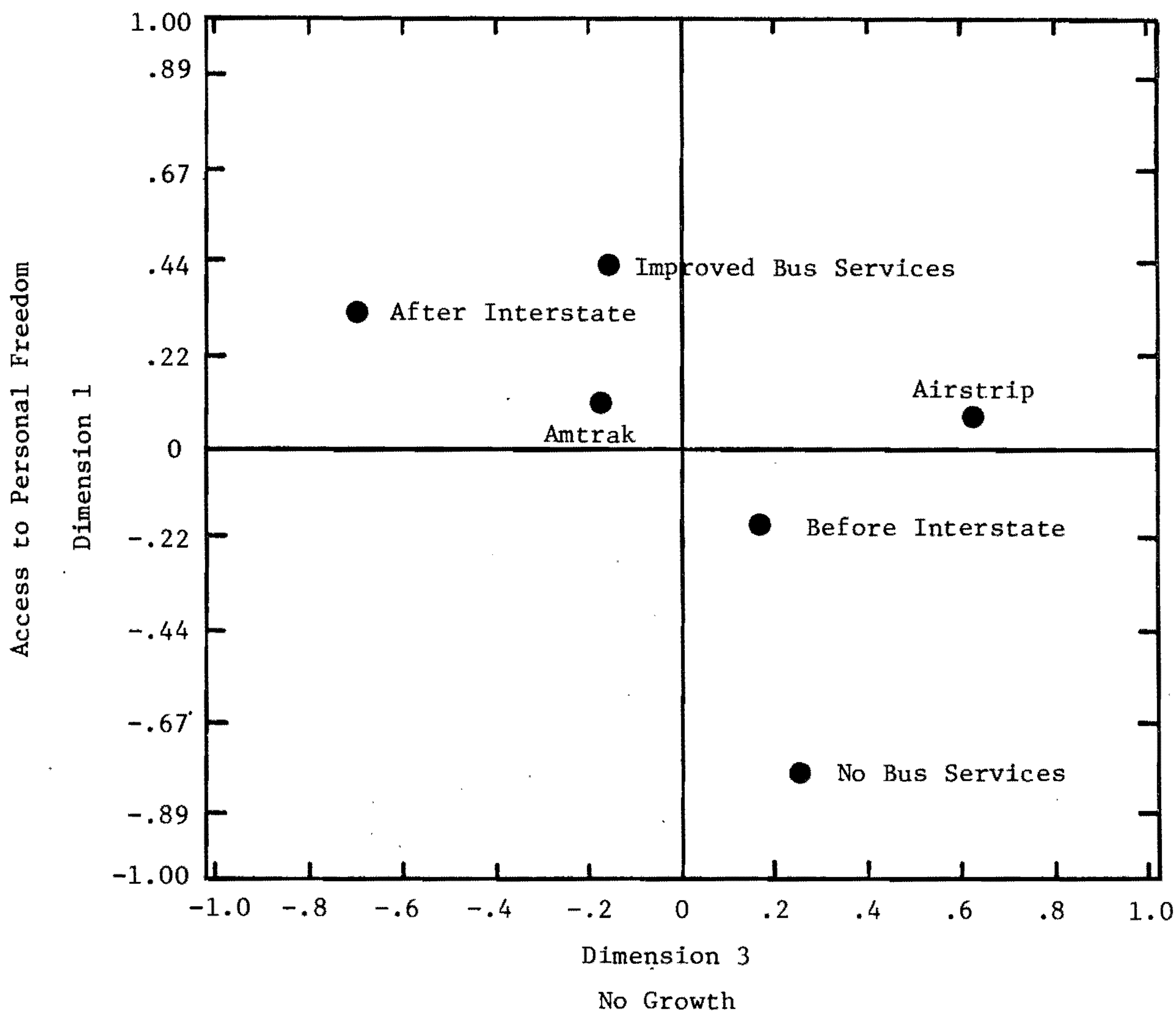


Figure 5b. INDSCAL plot of transportation alternatives-Group 1, Dimensions 1 and 3.

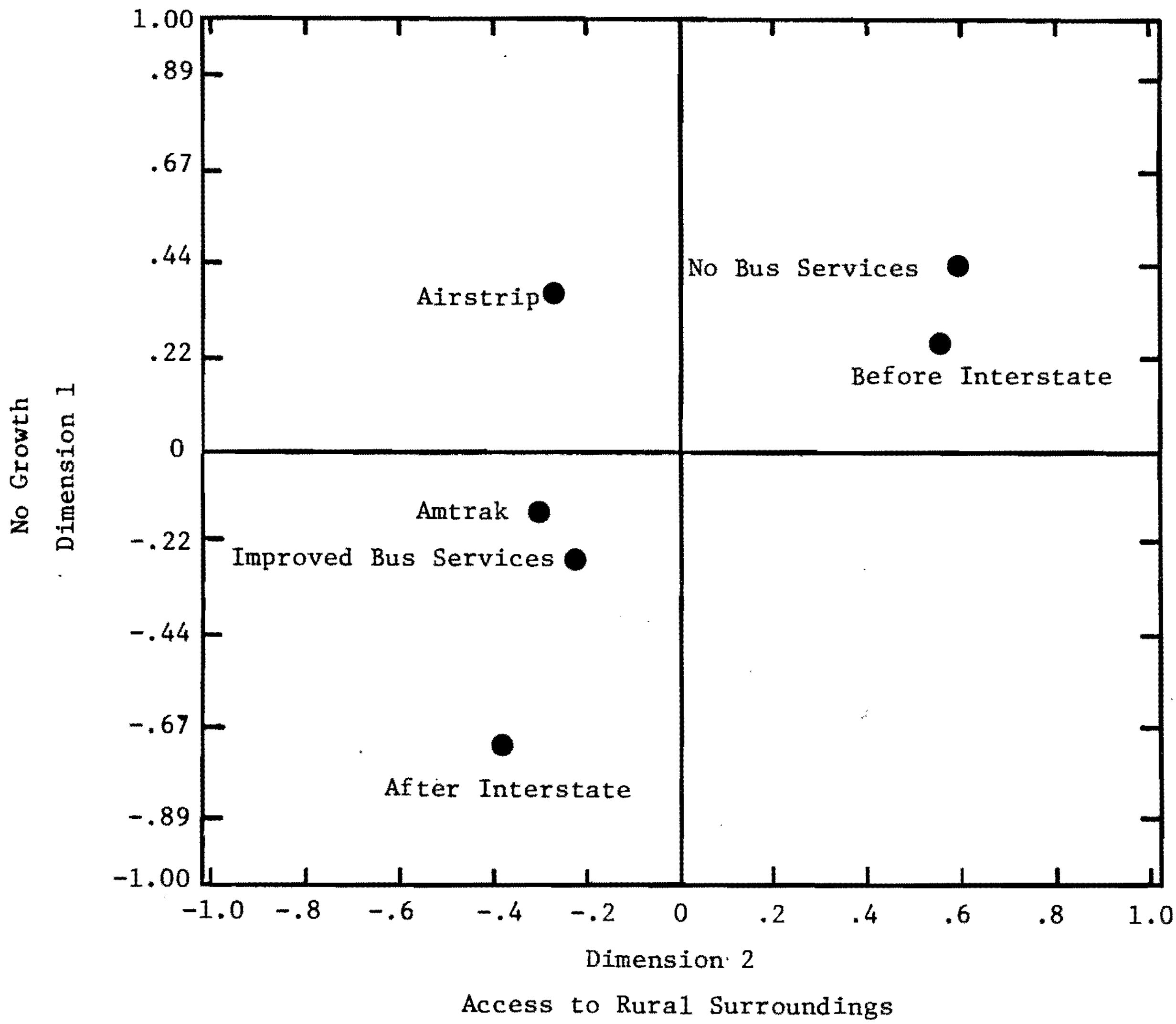


Figure 6a. INDSCAL plot of transportation alternatives-Group 2, Dimensions 1 and 2.

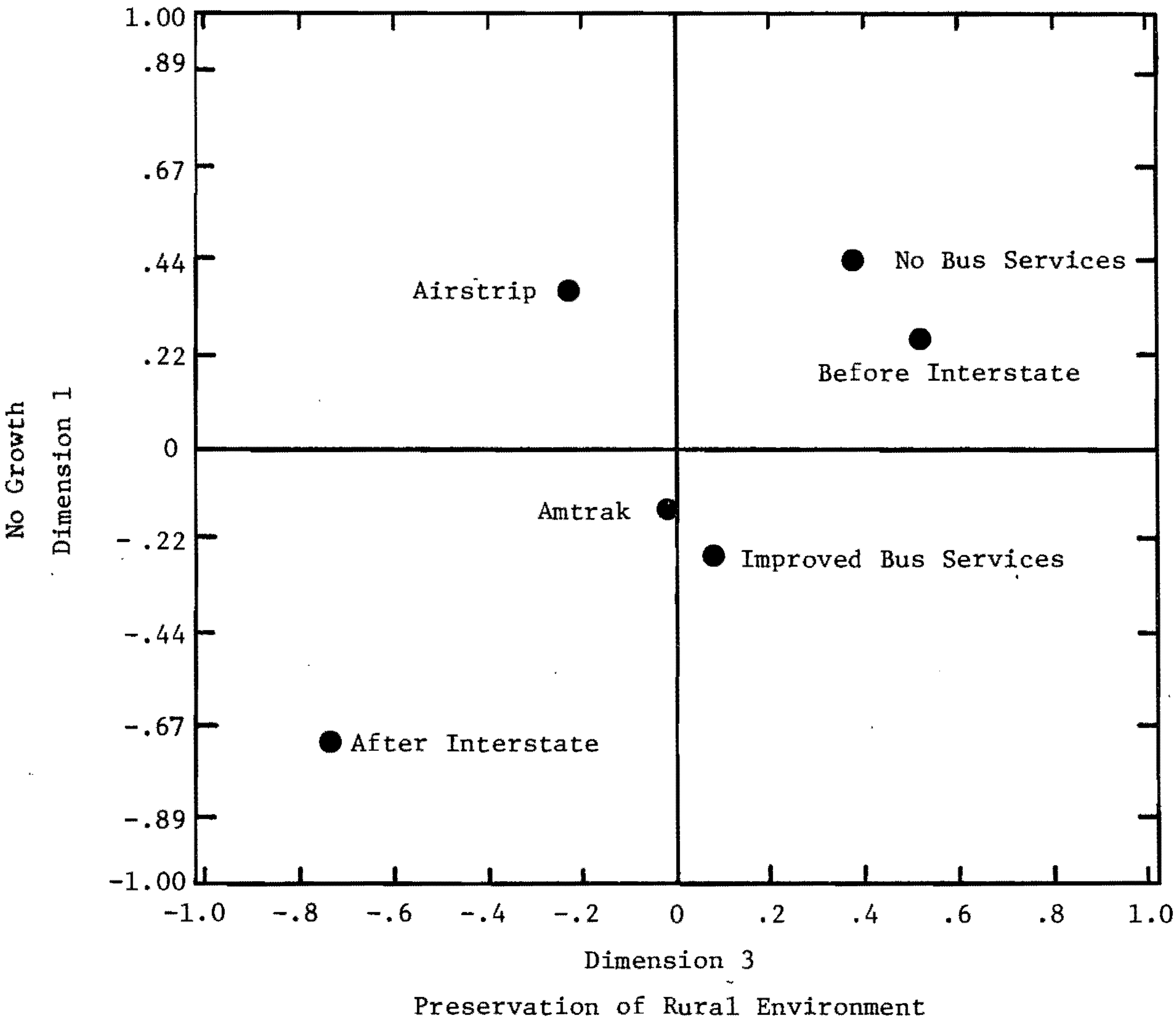


Figure 6b. INDSCAL plot of transportation alternatives-Group 2, Dimensions 1 and 3.

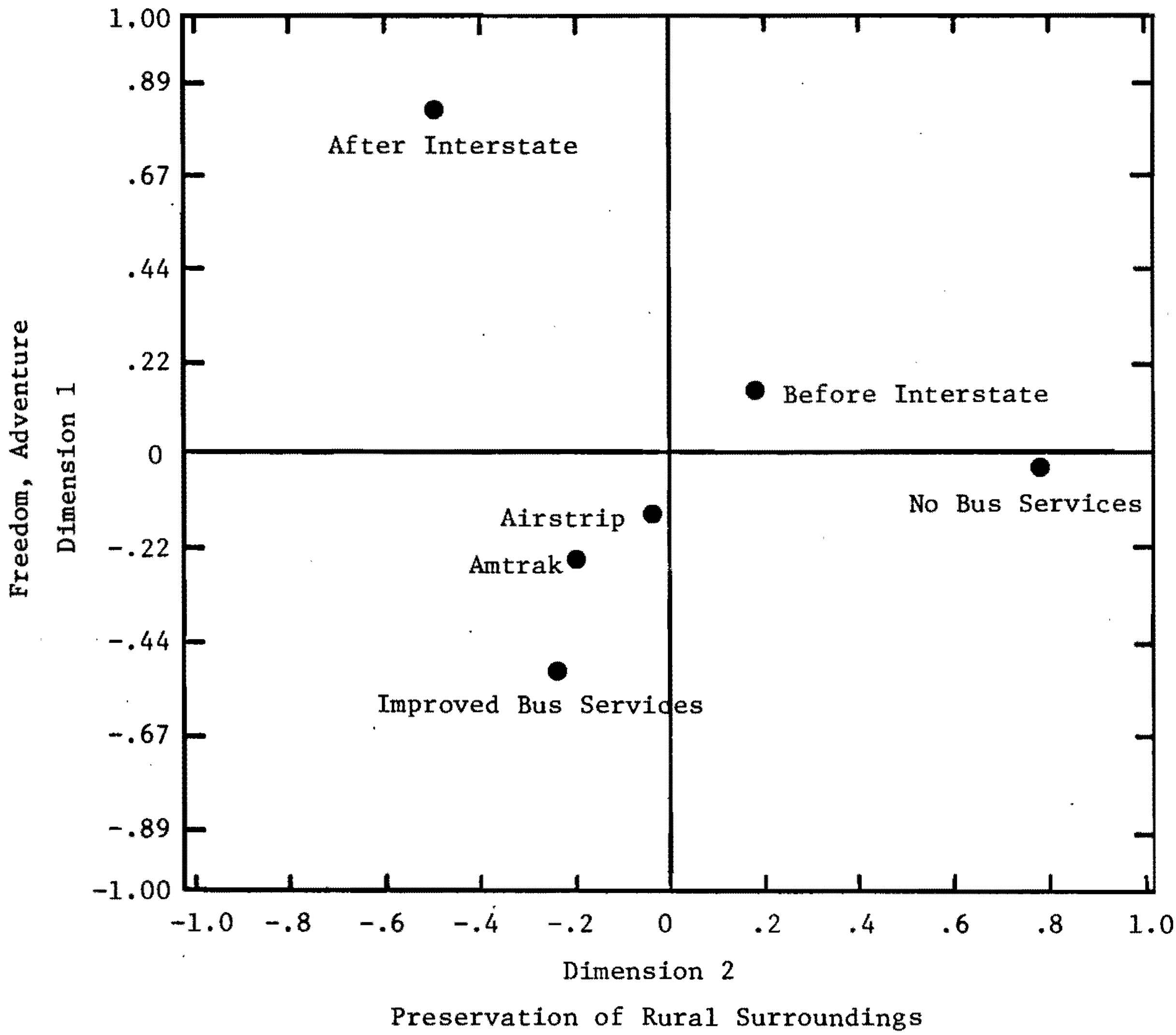


Figure 7a. INDSCAL plot of transportation alternatives-Group 3, Dimensions 1 and 2.

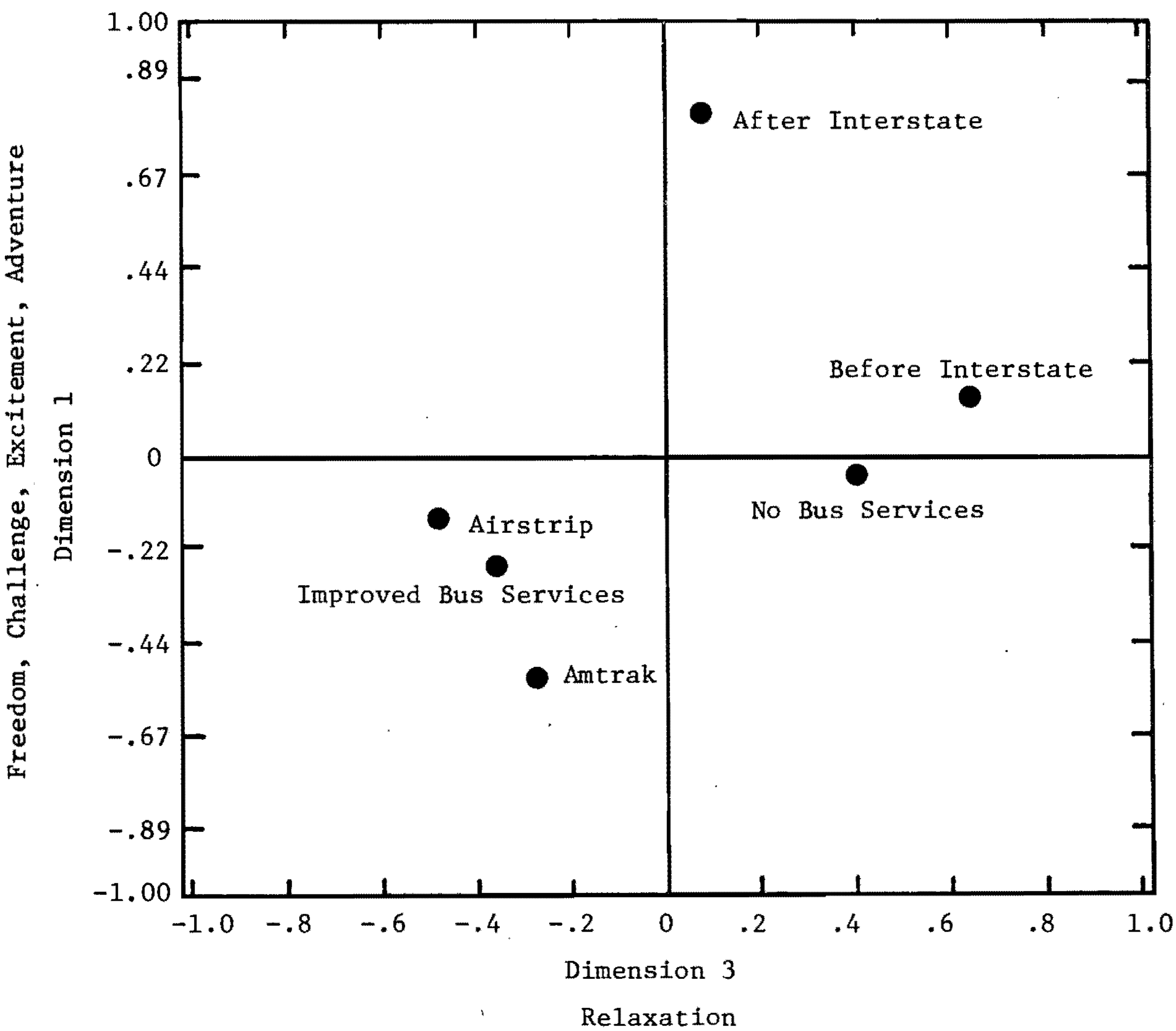


Figure 7b. INDSCAL plot of transportation alternatives-Group 3, Dimensions 1 and 3.

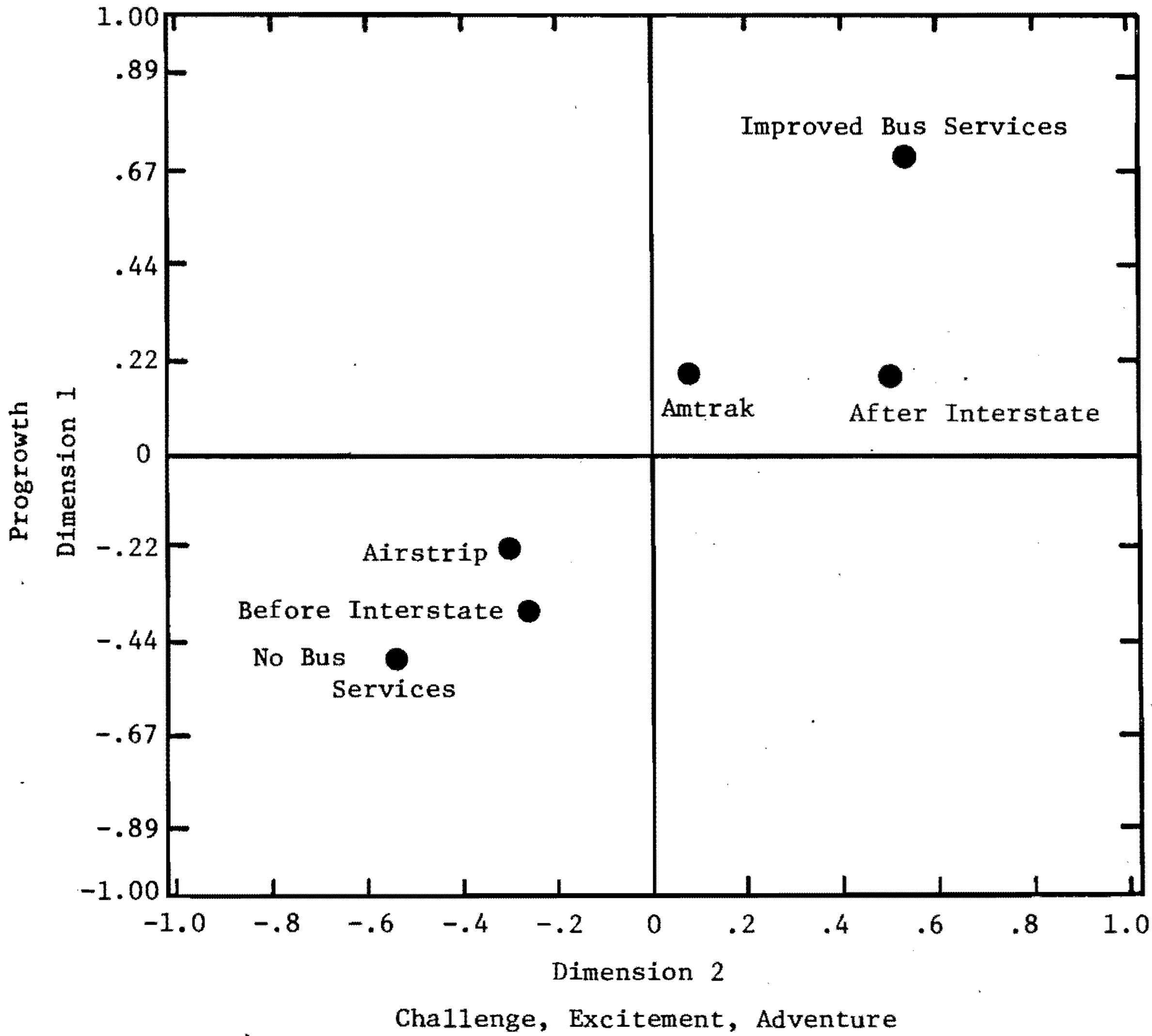


Figure 8a. INDSCAL plot of transportation alternatives-Group 4, Dimensions 1 and 2.

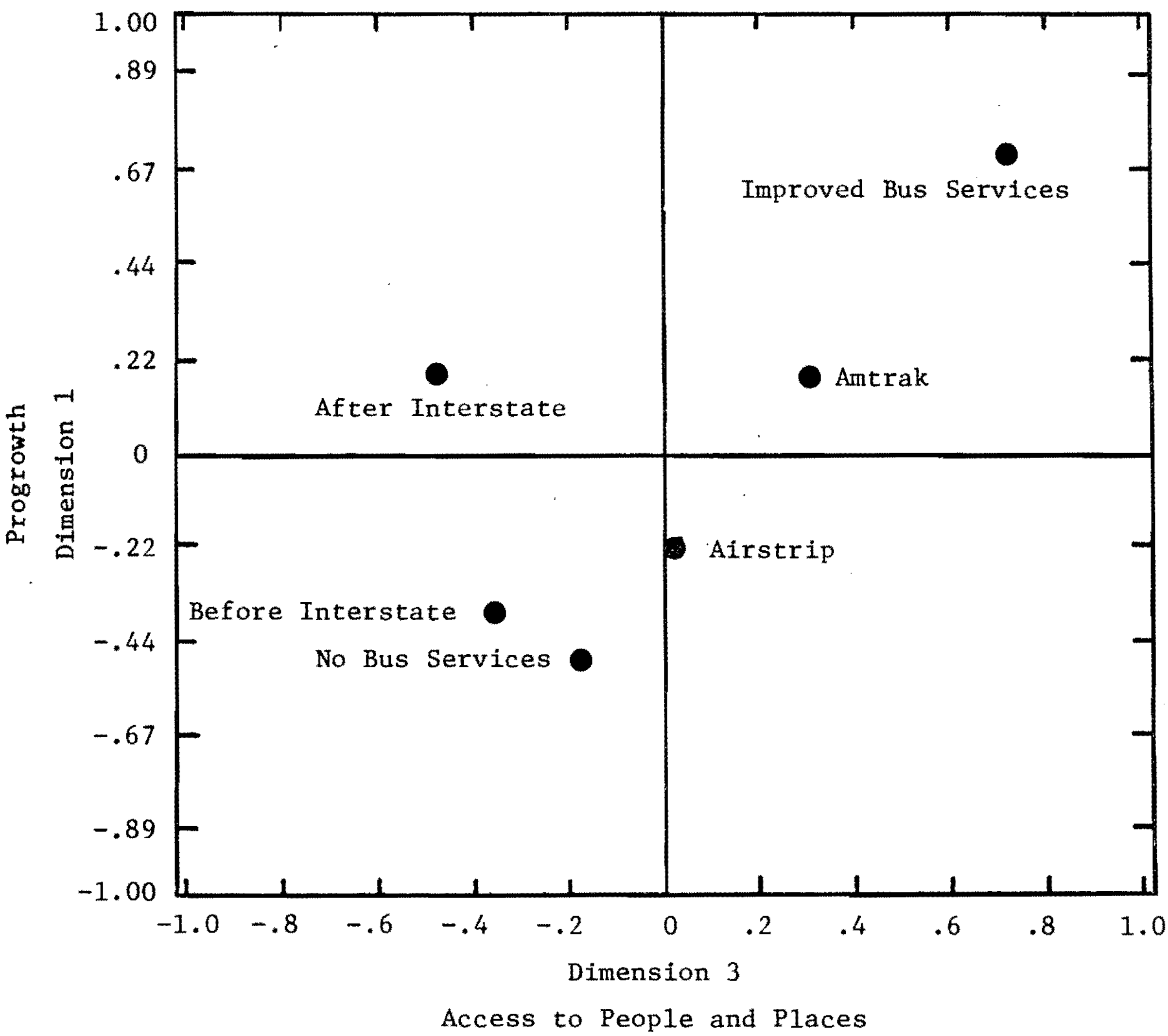


Figure 8b. INDSCAL plot of transportation alternatives-Group 4, Dimensions 1 and 3.

TABLE 7. AVERAGE SCORES FOR ALL TRANSPORTATION SYSTEMS ON ENVIRONMENTAL COMPONENTS (1.000 = HIGHEST; 7.000 = LOWEST)

Component	Group 1	Group 2	Group 3	Group 4
1. Attractiveness to industry	3.8	3.9	3.8	4.0
2. Attractiveness to retailing and office	3.6	3.2	3.4	4.0
3. Respondent's household income	3.4	3.1	3.5	2.2
4. Community income	3.7	3.9	3.8	4.0
5. Neighbourhood land values	3.6	3.7	4.0	3.9
6. Population growth	3.4	3.2	3.0	2.6
7. Preservation of family ties and friendships	3.4	3.3	3.7	3.2
8. Enjoyable outdoor recreation with others	3.5	3.4	3.4	3.6
9. Personal freedom	3.4	3.4	3.3	3.3
10. Country-western activities	3.9	3.9	4.0	4.0
11. Access to sophisticated entertainment	3.6	3.6	4.6	3.5
12. Restraints on behaviour	3.7	3.8	3.7	4.0
13. Challenge, excitement, adventure	3.3	3.5	3.3	3.7
14. Informal relationships	3.6	3.5	3.7	4.0
15. Access to luxuries of life	3.4	3.3	3.6	3.3
16. Pressure to achieve	3.7	3.8	3.7	4.0

(Cont.)

TABLE 7. AVERAGE SCORES FOR ALL TRANSPORTATION SYSTEMS ON ENVIRONMENTAL COMPONENTS (1.000 = HIGHEST; 7.000 = LOWEST) (Cont.)

Component	Group 1	Group 2	Group 3	Group 4
17. Peace, tranquility	3.7	4.0	4.7	2.7
18. Relaxation	3.9	4.0	3.8	3.1
19. Routine activities	3.7	3.5	3.9	3.1
20. Attractive rural surroundings	3.7	3.4	3.9	3.5
21. Intellectual stimulation	3.7	3.5	4.5	3.0
22. Accessibility to people and places	3.7	3.4	4.3	4.4
23. Personal privacy	3.8	3.8	4.8	4.0

Group 2 is not too dissimilar from Group 1 in that it scores very high for systems which generate low economic growth and is slightly more concerned about the effects of growth on the environment (Table 7, Column 2). Thus, for this group too, Dimension 1 seems a no-growth dimension, with facilities leading to growth given an unfavorable score and those not doing so being given a favorable score (Figure 6a). Dimension 2 seems a dimension associated with access to places for informal but stimulating relationships: facilities providing close countryside access score favorably while those providing access to distant, more sophisticated places score unfavorably (Table 7, Column 2). Dimension 3 seems associated with the stability of the rural community before modern transportation systems were suggested: the presence of the freeway scores negatively and is polarized against its absence (Figure 6b). This group scored favorably systems giving routine activities and the preservation of family ties and friendships. Consequently, this dimension is named preservation of rural environment.

The dimensions for the other groups were named in a similar fashion and are as follows: (a) Group 3: access to personal freedom; preservation of rural surroundings; relaxation; (b) Group 4: growth rather than antigrowth; challenge, excitement, and adventure; access to people and places.

The fact that the four groups showed some communality in their dimensions suggests that the town is unified rather than divided about the advantages and disadvantages of alternative transportation systems. This is not the case, however; the INDSCAL diagrams present only composite or group viewpoints. Figure 9 shows how much individuals within a group can vary in the importance which they attach to the different dimensions. The dispersion of weights shown for Group 1 is typical.[26] It is therefore of interest whether these

[26] Some of the weights in the space are negative. A personal communication from Prof. R. G. Golledge, Ohio State University, July 16, 1975, indicated that this is not too uncommon a result. In a case like the present one, some subjects could plausibly be negatively weighting some of the dimensions, for example, the dimension concerning economic growth. Considerable controversy over the importance of the dimensions is to be expected in a small town.

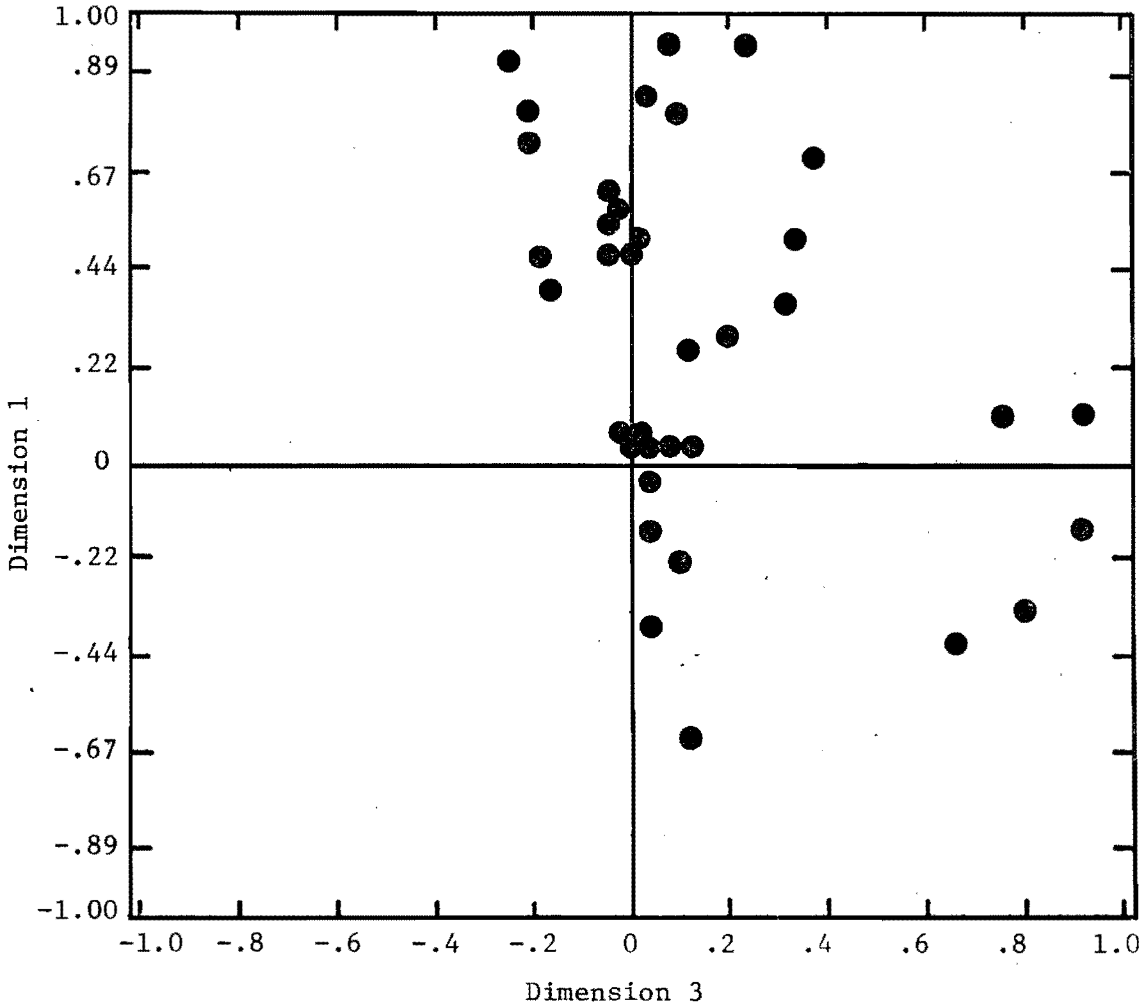


Figure 9. Subject weights for Group 1 on Dimensions 1 and 3.

groups, which are homogeneous socioeconomically and in terms of activity patterns, do represent, as previously believed, homogeneous interest groups in terms of the transport systems, particularly with respect to whether their different members will oppose or defend such systems. The analyses of the utilities which INDSCAL supplied for each respondent help answer this question.

Table 8 has been drawn up to show how different members within a group may derive their maximum environmental utilities under different transportation systems. For example, in Group 1, 17/43 people (39.5%) saw their maximum utility coming under the status quo, after the introduction of the interstate highway. However, 26 (60.4%) wanted alterations in the transportation systems to make the environment more desirable: 9 (20.9%) perceived greater benefit with improved bus services, 8 (18.6%) wanted mass transit facilities deleted altogether, and 9 (20.9%) saw their maximum benefit with the addition of an airstrip.

Thus, despite the one central hypothesis in this paper that different homogeneous socioeconomic groups would be supportive of one favorite alternative, the INDSCAL analysis reveals this is not the case. The differential cognitions and evaluations of group members lead to interest groups with supporters drawn from different socioeconomic strata. For example, Column 2 of Table 8 shows that the post-highway status quo is supported by 17 (39.5%) members of homogeneous Group 1, 14 (48.3%) of Group 2, and 2 (50.0%) of Group 3 in the case study community. This result is interesting in itself. However, its main value is to demonstrate how the INDSCAL framework can be applied to predict ultimately political responses to transportation alternatives in an urban area.

TABLE 8. NUMBER AND PERCENTAGE OF RESPONDENTS WITH MAXIMUM UTILITIES FOR TRANSPORTATION ALTERNATIVES

	Before Highway	After Highway	Add Train Stop	Improve Bus Services	Delete Bus Services	Add Air Strip	Totals
Group 1		17(39.5)		9(20.9)	8(18.6)	9(20.9)	43(100.0)
Group 2		14(48.3)			13(44.8)	2(6.9)	29(100.00)
Group 3	1(25.0)	2(50.0)			1(25.0)		4(100.0)
Group 4				2(100.0)			2(100.0)
Total	1(1.2)	33(42.3)		11(14.1)	22(28.2)	11(14.1)	78(100.0)

Percentages in parentheses

PART IV

CONCLUSION

This report has presented a framework for analyzing how residents of urban environments themselves perceive and evaluate transportation alternatives. A two phase design was described. In the first phase, a procedure was developed for eliciting the components which residents conceive as comprising their environment under a transportation system. For this, Kelly's Personal Construct Theory and Repertory Grid procedures were used. An example was given of the elicitation of the components which describe the environments of small town residents.

The second phase was more complex. It was hypothesized that, in a sample population, there might be groups who would (a) be homogeneous according to a very wide range of non-traditional socioeconomic and activity variables and (b) evaluate the components of their kind of environment in the same way under alternative transportation systems. Accordingly, the conceptual framework was extended to define statistically homogeneous groups, using income, occupation, age, and many different kinds of travel behaviors. This framework was successfully tested with the definition of four homogeneous groups in a case study small town. Finally, the INDSCAL model was employed to determine whether each homogeneous group does evaluate the components of their kind of environment under alternative transportation systems in a distinctive way. For the kinds of homogeneous groups in the case study town it was found that they do not. Each group evaluates transportation systems along similar dimensions, but individual differences within groups are so great that some members derive maximum utility from one alternative and some from another. Thus, other kinds of interest groups which support or oppose transportation innovations are drawn from different socioeconomic and activity groupings. The conceptual framework of this paper demonstrates how such interest groups are derived.

BIBLIOGRAPHY

Amir, S., "Highway location and public opposition," Environment and Behavior, 4, (1972), 413-436.

Bannister, D., "Personal construct theory; a summary and experimental paradigm," Acta Psychologica, 20 (1962), 104-120.

Bannister, D. and J. M. M. Mair. The Evaluation of Personal Constructs London: Academic Press, 1963.

Berry, B. J. L. (ed.) Comparative Factorial Ecology (Special edition) Economic Geography, 47, Supplement (1971).

Berry, B. J. L. and P. Rees, "The factorial ecology of Calcutta," American Journal of Sociology (1969), 455-491.

Bonnarius, J. C. J., "Research in the personal construct theory of George A. Kelly: role construct repertory test and basic theory," in B. A. Mahr, (ed.), Progress in Experimental Personality Research. New York: Academic Press, 1965, pp. 1-46.

Bourne, L. S. and R. A. Murdie, "Interrelationships of social and physical space in the city: a multivariate analysis of Metropolitan Toronto," Canadian Geographer, 16, (1972) 211-229.

Brown, L. and E. G. Moore, "The intra-urban migration process: a perspective," Geografiska Annaler, 52, Series B (1970), 1-13.

Burkhardt, J. E., "Community reactions to anticipated freeways: fears and actual effects Highway Research Record, No. 470 (1973), 22-31.

Burnett, P., J. Betak, D. Chang, W. Enders, J. Montemayor. Transportation Related Constructs of Activity Spaces of Small Town Residents. Research Report 18, Council for Advanced Transportation Studies, The University of Texas at Austin, 1974.

Burnett, K. P., "Decision processes and innovations: a transportation example," Economic Geography, 51 (1975), 278-289.

Carroll, J. D., "Individual Differences and Multidimensional Scaling," in R. N. Shepard, A. K. Romney and S. B. Nerlove (Eds.) Multidimensional Scaling. Volume 1: Theory. New York: Seminar Press, 1972, pp. 105-155.

Epting, F. R., D. I. Suchman, and C. J. Nickerson, "An evaluation of elicitation procedures for personal constructs," British Journal of Psychology, 62 (1971), 513-517.

Fellman, G., "Neighborhoods protest of an urban highway," Journal of the American Institute of Planners, 35 (1969), 118-122.

Fretzsche, D. J., "Consumer response information - a potential tool for regulatory decisionmakers," Transportation Journal, 14 (1974), 22-26.

Gonen, A., "The Spadina Expressway conflict in Toronto: decision and opposition," Discussion Paper, No. 5, Research on Conflict on Locational Decisions, Department of Regional Science, University of Pennsylvania, Philadelphia, 1970.

Green, P. E. and V. R. Rao. Applied Multidimensional Scaling New York: Holt, Rinehart, and Winston, 1972.

Harrison, J. and P. Sarre, "Personal construct theory in the measurement of environmental images: problems and methods," Environment and Behavior, 3 (1971), 351-374.

Hinman, J. "Controversial facility-complex programs: coalitions, side-payments, social decisions," Discussion Paper, No. 8, Research on Conflict on Locational Decisions, Department of Regional Science, University of Pennsylvania, Philadelphia, 1970.

Horton, F. E. and D. R. Reynolds, "The investigation of individual action spaces: a progress report," Proceedings of the Association of American Geographers, 1 (1969), 70-74.

Hunter, G. C., "Rural communities and inter-urban transportation systems: a study of the stages of interaction," Unpublished Master's Thesis, Department of Architecture, University of Texas at Austin, 1974.

Johnston, R. J., "Activity spaces and residential preferences: some tests of the hypothesis of sectoral mental maps," Economic Geography, 48 (1972), 199-211.

Kaplan, Gans and Kahn. Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvements. San Francisco: Marshall Kaplan, Gans and Kahn, 1972.

Kelly, G. A. The Psychology of Personal Constructs. New York: W. W. Norton, 1955.

Manheim, M. L., et al., Community Values in Highway Location and Design: A Procedural Guide: Final Report. Cambridge, Mass: M. I. T. Urban Systems Laboratory, 1971.

Murphrey, A. J., "The New Orleans riverfront expressway controversy: an analytical account," Discussion Paper, No. 1, Research on Conflict on Locational Decisions, Department of Regional Science, University of Pennsylvania, Philadelphia, 1970.

Mumphrey, A. J., "A Monte Carlo simulation of highway planning and citizen opposition: the Pennsylvania planning opposition simulation," Discussion Paper, No. 9, Research on Conflict on Locational Decisions, Department of Regional Science, University of Pennsylvania, Philadelphia, 1971.

Nasatir, D. The Social Consequences of BARTS Environmental Impact: Some Preliminary Considerations and Hypotheses. Berkeley, California: University of California at Berkeley, 1974.

Nicholaidis, G. C., "Quantification of the comfort variable," Transportation Research, 9 (1975), 55-66.

Rummel, R. J., "Understanding factor analysis," Journal of Conflict Resolution, 40, (1967), 440-480.

Ryan, C., et al. "A review of the public hearing process as a means of obtaining citizens' views and values," Highway Research Record, No. 467 (1974), 24-25.

Schermer, J. H., "Interest group impact assessment in transportation planning," Traffic Quarterly, 39 (1975), 29-49.

Seley, J. E., "Development of a sophisticated opposition: the Lower Manhattan expressway issue Discussion Paper, No. 2, Research on Conflict on Locational Decisions, Department of Regional Science, University of Pennsylvania, Philadelphia, 1970.

Shepard, R. N., A. K. Romney, S. B. Nerlove (eds.) Multidimensional Scaling: Volume 1: Theory. New York: Seminar Press, 1972.

Slater, P., "Theory and techniques of the repertory grid," British Journal of Psychiatry, 115 (1969), 1287-1296.

Slater, P., Notes on INGRID 72. London: Institute of Psychiatry, 1972.

Sloan, A. K., Citizen Participation in Transportation Planning: the Boston Experience. Cambridge, Mass.: Ballinger, 1974.

Ward, J. H., Jr., "Hierarchical grouping to optimize an objective function," Journal for the American Statistical Association, 58 (1963), 236-244.

RESEARCH MEMORANDA PUBLISHED BY
THE COUNCIL FOR ADVANCED TRANSPORTATION STUDIES

1 *Human Response in the Evaluation of Modal Choice Decisions.* C. Shane Davies, Mark Alpert, and W. Ronald Hudson, April 1973.

2 *Access to Essential Services.* Ronald Briggs, Charlotte Clark, James Fitzsimmons, and Paul Jensen, April 1973.

3 *Psychological and Physiological Responses to Stimulation.* D. W. Wooldridge, A. J. Healey, and R. O. Stearman, August 1973.

4 *An Intermodal Transportation System for the Southwest: A Preliminary Proposal.* Charles P. Zlatkovich, September 1973.

5 *Passenger Travel Patterns and Mode Selection.* Shane Davies, Mark Alpert, Harry Wolfe, and Rebecca Gonzalez, October 1973.

6 *Segmenting a Transportation Market by Determinant Attributes of Modal Choice.* Shane Davies and Mark Alpert, October 1973.

7 *The Interstate Rail System: A Proposal.* Charles P. Zlatkovich, December 1973.

8 *Literature Survey on Passenger and Seat Modeling for the Evaluation of Ride Quality.* Bruce Shanahan, Ronald Stearman, and Anthony Healey, November 1973.

9 *The Definition of Essential Services and the Identification of Key Problem Areas.* Ronald Briggs and James Fitzsimmons, January 1974.

10 *A Procedure for Calculating Great Circle Distances Between Geographic Locations.* J. Bryan Adair, March 1974.

11 *MAPRINT: A Computer Program for Analyzing Changing Locations of Non-Residential Activities.* Graham Hunter, Richard Dodge, and C. Michael Walton, March 1974.

12 *A Method for Assessing the Impact of the Energy Crisis on Highway Accidents in Texas.* E. L. Frome and C. Michael Walton, February 1975.

13 *State Regulation of Air Transportation in Texas.* Robert C. Means and Barry Chasnoff, April 1974.

14 *Transportation Atlas of the Southwest.* Charles P. Zlatkovich, S. Michael Dildine, Eugene Robinson, James W. Wilson, and J. Bryan Adair, June 1974.

15 *Local Governmental Decisions and Land-Use Change: An Introductory Bibliography.* W. D. Chipman, May 1974.

16 *An Analysis of the Truck Inventory and Use Survey Data for the West South Central States.* Michael Dildine, July 1974.

17 *Towards Estimating the Impact of the Dallas-Fort Worth Regional Airport on Ground Transportation.* William J. Dunlay and Lyndon Henry, September 1974.

18 *The Attainment of Riding Comfort for a Tracked Air-Cushion Vehicle Through the Use of an Active Aerodynamic Suspension.* Bruce Shanahan, Ronald Stearman, and Anthony Healey, September 1974.

19 *Legal Obstacles to the Use of Texas School Buses for Public Transportation.* Robert Means, Ronald Briggs, John E. Nelson, and Alan J. Thiemann, January 1975.

20 *Pupil Transportation: A Cost Analysis and Predictive Model.* Ronald Briggs and David Venhuizen, April 1975.

21 *Variables in Rural Plant Location: A Case Study of Sealy, Texas.* Ronald Linehan, C. Michael Walton, and Richard Dodge, February 1975.

22 *A Description of the Application of Factor Analysis to Land Use Change in Metropolitan Areas.* John Sparks, Carl Gregory, and Jose Montemayor, December 1974.

23 *A Forecast of Air Cargo Originations in Texas to 1990.* Mary Lee Metzger Gorse, November 1974.

24 *A Systems Analysis Procedure for Estimating the Capacity of an Airport: A Selected Bibliography.* Chang-Ho Park, Edward V. Chambers, III, and William J. Dunlay, Jr., August 1975.

25 *System 2000—Data Management for Transportation Impact Studies.* Gordon Derr, Richard Dodge, and C. Michael Walton, September 1975.

26 *Regional and Community Transportation Planning Issues: A Selected Bibliography.* John Huddleston, Ronald Linehan, Abdulla Sayyari, Richard Dodge, C. Michael Walton, and Marsha Hamby, September 1975.

27 *A Systems Analysis Procedure for Estimating the Capacity of an Airport: System Definition, Capacity Definition, and Review of Available Models.* Edward V. Chambers, III, Tommy Chmores, William J. Dunlay, Jr., Nicolau D. F. Gualda, B. F. McCullough, Chang-Ho Park, and John Zaniewski, October 1975.

28 *The Application of Factor Analysis to Land Use Change in a Metropolitan Area.* John Sparks and Jose Montemayor, November 1975.

29 *Current Status of Motor Vehicle Inspection: A Survey of Available Literature and Information.* John Walter Ehrfurth and David A. Sands, December 1975.

30 *Executive Summary: Short Range Transit Improvement Study for The University of Texas at Austin.* C. Michael Walton, May 1976.

31 *A Preliminary Analysis of the Effects of the Dallas-Fort Worth Regional Airport on Surface Transportation and Land Use.* Harry Wolfe, April 1974.

32 *A Consideration of the Impact of Motor Common Carrier Service on the Development of Rural Central Texas.* James Wilson, February 1975.

33 *Modal Choice and the Value of Passenger Travel Time Literature: A Selective Bibliography.* Shane Davies and Mark I. Alpert, March 1975.

34 *Forecast of Air Cargo Originations in Arkansas, Louisiana, and Oklahoma to 1990.* Deborah Goltra, April 1975.

35 *Inventory of Freight Transportation in the Southwest/Part IV: Rail Service in the Dallas-Fort Worth Area.* Charles P. Zlatkovich, Mary L. Gorse, Edward N. Kasparik, and Dianne Y. Priddy, April 1975.

36 *Forecast of Waterborne Commerce Handled by Texas Ports to 1990.* Stuart Metz Dudley, April 1975.

37 *Forecast of Refinery Receipts of Domestic Crude Oil from Pipelines in the West South Central States to 1990.* Mary L. Gorse, Dianne Y. Priddy, and Deborah J. Goltra, April 1975.

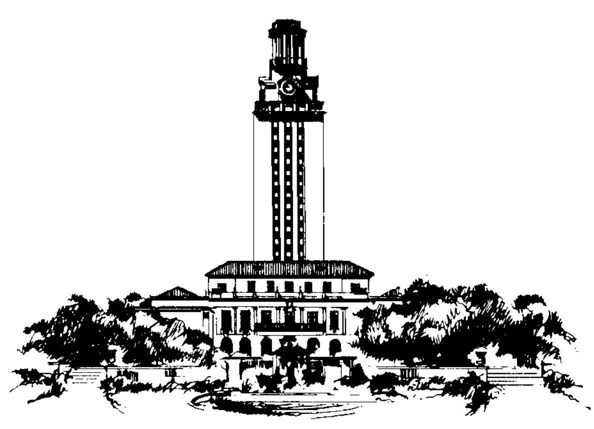
38 *A Feasibility Study of Rail Piggyback Service Between Dallas-Fort Worth and San Antonio.* Edward N. Kasparik, April 1975.

39 *Land Value Modeling in Rural Communities.* Lidvard Skorpa, Richard Dodge, and C. Michael Walton, June 1974.

40 *Toward Computer Simulation of Political Models of Urban Land Use Change.* Carl Gregory, August 1975.

41 *A Multivariate Analysis of Transportation Improvements and Manufacturing Growth in a Rural Region.* Ronald Linehan, C. Michael Walton, and Richard Dodge, October 1975.

42 *A Transit Demand Model for Medium-Sized Cities.* John Shortreed, December 1975.



Council for Advanced Transportation Studies

THE UNIVERSITY OF TEXAS AT AUSTIN