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DOI:
10.2307/490998

Document status and date:
Published: 01/01/1981

Document Version:
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

SPATIAL CHOICE BEHAVIOUR IN DIFFERENT ENVIRONMENTAL SETTINGS: AN APPLICATION OF THE REVEALED PREFERENCE APPROACH

BY

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ABSTRACT. This paper is concerned with the idea of invariant preference structures. At the outset, it is argued that empirical tests on the transferability of preference functions to other regions are necessary to substantiate the claim that behavioural models represent valuable ways of assessing the impact of environmental planning programs.

Subsequently, the findings of an empirical study of spatial shopping choice behaviour in two Dutch regions are considered. It is demonstrated that, using Rushton's preference scaling methodology, the preference functions pertaining to one group of respondents in one particular region can be used successfully to predict aggregate spatial shopping patterns of an entirely different group of respondents living in a completely different environmental setting.

Introduction

Since the late 1960's, a substantial body of research findings have been generated dealing with individual spatial choice behaviour. This work has consciously attempted to understand and explain aggregate spatial movement patterns in terms of individual spatial decision-making processes giving rise to these large-scale patterns. The need for such a cognitive-behavioural approach in part originated from scholar's desires to develop models whose parameters are independent of any particular spatial structure and which, consequently, would be of great practical value in terms of the evaluation of alternative environmental planning programs. It was further emphasized by the results of numerous studies indicating that the classical distance-minimising postulate of spatial economic theory was very unrealistic (Clark and Rushton 1970; Rushton, 1969a, 1971a).

Ultimately, the cognitive-behavioural approach has been directed toward establishing links between spatial structures, the perception and evaluation of these structures, and spatial behaviour. In practice, however, operational models including all three elements have been few. Instead, most studies have been dealing with only one element or one link. Thus, several studies have investigated the nature of individual's perceptual or information fields and evaluation functions for varying locational decisions (e.g. Downs, 1970; Burnett, 1973; Hudson 1974; Mackay and associates, 1975; Knight and Menchik 1976; Louviere 1976, Potter 1976a–b, 1977a–b–c, 1978, 1979; Hanson 1976, 1977; Smith 1976; Aldskogius 1977; Golledge and Spector 1978; Cox et.al. 1979; Smith et.al. 1979), while a completely separate body of empirical and theoretical work has been concerned with the quantitative linkage of such behavioural traits as preferences, cognitions, evaluations and attitudes to overt spatial choice behaviour (e.g. Cadwallader 1975, Hudson 1976; Pipkin 1977; Lieber 1978, 1979; Lloyd and Jennings 1978; Recker and Kostyniuk 1978). Although it is evident that our knowledge of the factors influencing spatial decision-making has been greatly enlarged, it is by no means sufficient nor appropriate for the evaluation of planning programs. Only an integral approach establishing quantitatively the relationships between objective attributes of spatial alternatives, their psychological counterparts and spatial choice behaviour will admit to forecasting in a planning context.

In addition to the lack of attention focused upon an integral approach, little research effort has been spent on testing whether a behavioural model calibrated on data pertaining to one group of respondents in one particular study area can be used to predict the choice behaviour of a totally different group of individuals located in an entirely different environmental setting. Despite the fact that much work in the cognitive-behavioural tradition has been based implicitly

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upon the premise that behavioural geography will be able to give fundamental descriptions of spatial behaviour which are place independent, that is, which are unlikely to vary significantly from one area to another, unless major cultural boundaries are crossed (Rushton 1971c), very few studies indeed have addressed the issue of generalizability or transferability of their results. It is the author's contention, however, that if behavioural geography is to contribute to the solving of problems involved in the evaluation of environmental planning programs, it is first necessary to provide further empirical evidence supporting the claim that the parameters of the behavioural models are not contingent upon the structure of the particular spatial system being studied.

The principal aim of the present study is to discuss the issue of transferability of behavioural models in the context of spatial shopping behaviour. Specifically, the idea of invariant preference structures is empirically tested. In addition, the predictive ability of the preference scaling model under different initial conditions will be assessed. It is specifically in this respect that the present study extends previous theoretical and empirical work on the use of Rushton's preference scaling model (Rushton, 1969c, 1971b–c, 1976; Lentnek, Lieber and Sheskin, 1975; Girt, 1976, 1977; Lieber, 1977; Timmermans, 1979).

Expressed versus revealed preferences

Behavioural geography has provided at least two alternative ways of deriving consumer preference structures. One way is to derive preference structures from overt behaviour (e.g. Rushton, 1969a–b). This approach presupposes that if an individual chooses a particular spatial alternative, he reveals his preference in favour of that alternative and his rejection of the other available alternatives. By defining the alternatives as combinations of stimuli, a preference structure is found by scaling a matrix, showing the perceived dissimilarities between the spatial alternatives. Another approach is to ask respondents to express their preference toward a number of alternatives in (quasi-)laboratory experiments (e.g. Prosperi and Schuler, 1976; Schuler and Prosperi, 1978; Schuler, 1979; Lieber, 1978, 1979; Louviere and Meyer, 1979). In these experiments, subjects are invited to give numerical or ordinal responses to hypothetical combinations of stimuli. Using these responses as inputs, preference structures or utility functions are analyzed by means of conjoint scaling methods or functional measurement approaches.

Technically, the approaches differ only gradually although the research designs associated with the approaches show some marked differences and each design has its own specific problems. However, each approach requires the a priori identification of the relevant stimuli and the specification of the class intervals of the stimuli. Moreover, although the methods of analyses involved seem to be associated uniquely with the approaches, there is no reason whatsoever for not using, for example, a conjoint scaling method in combination with the revealed preference approach (see also Rushton, 1976). The major technical difference between the two approaches, therefore, is that the experiments permit *a priori* estimates of preferences whereas the revealed preference approach is based upon *a posteriori* estimates of preferences.

Consequently, the debate on expressed versus revealed preferences should be viewed mainly from a conceptual and methodological perspective. Especially the revealed preference approach has been criticized on its conceptual weakness (Pirie, 1976; MacLennan and Williams, 1979). It has been argued that not all spatial choice behaviour is based upon preferences, that it is dangerous to interpret all observed behaviour in terms of underlying preferences, and that the revealed preference approach appears to reflect consistency of spatial choice rather than preference-based laws of spatial behaviour. On the other hand, Timmermans and Rushton (1979) have argued that the revealed preference approach can be used validly for interpreting spatial behaviour which can be taken to be relatively unconstrained by environmental and personal conditions. The question whether choice behaviour under such circumstances reflects underlying preferences rather than consistency of spatial choice appears to be a matter of definition. When using the approach for predictive purposes, a still more important issue seems to be that of generalizability or transferability. While one may argue over whether the results of the revealed preference approach reflect preferences, attitudes, judgments, choice regularities, or whatever, the legitimacy of the approach in a planning context is proven if it can be shown that

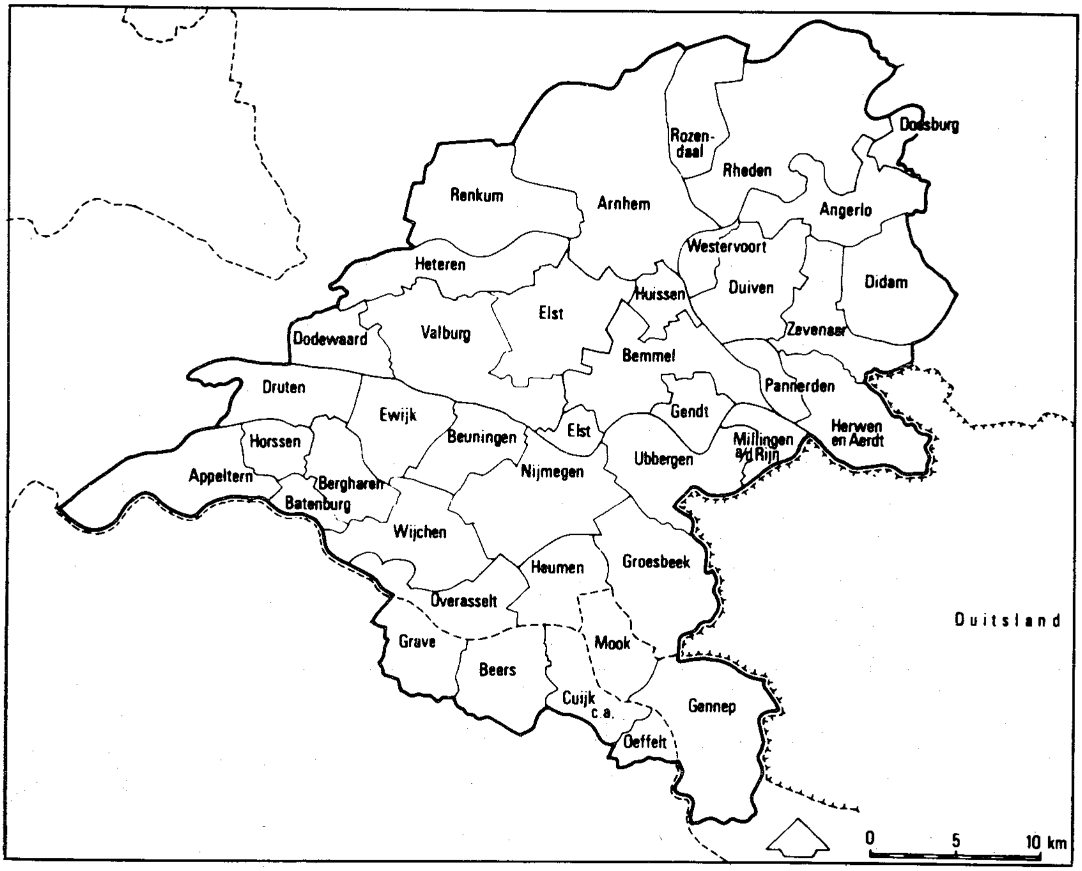

Fig. 1a. Study area M-Gelderland.

its predictive ability in different environmental settings is satisfactory.

In conclusion, the contention of the present author is that both ways can be used to recover consumer preferences, although none of these approaches is necessarily error free (see also Beavon and Hay, 1977).

The study areas and survey research design

In order to test the idea of invariant preference structures, data on consumer shopping behaviour were collected for two study areas, Friesland and Midden-Gelderland. The survey was carried out under responsibility of the Rijksplanologische Dienst (National Planning Agency) during the winter of 1977 and its design was founded in a number of conceptual considerations regarding the empirical viability of the functional hierarchy implication of central place theory vis-à-vis spatial consumer behaviour (RPD, 1978).

The two study areas are portrayed in Figure 1. Their selection has been based upon the condition that the study areas to be chosen should represent totally different environmental settings. The study area Friesland covers one of the northern provinces of the Netherlands. Its economy is dominated by the agricultural sector. This is reflected in the fact that 57.1 percent of its population lives in settlements of less than 10.000 inhabitants. The area is characterized by an uninodal structure with the municipality of Leeuwarden dominating the entire region. Furthermore, the study area Friesland has a negative migration balance indicating its backward

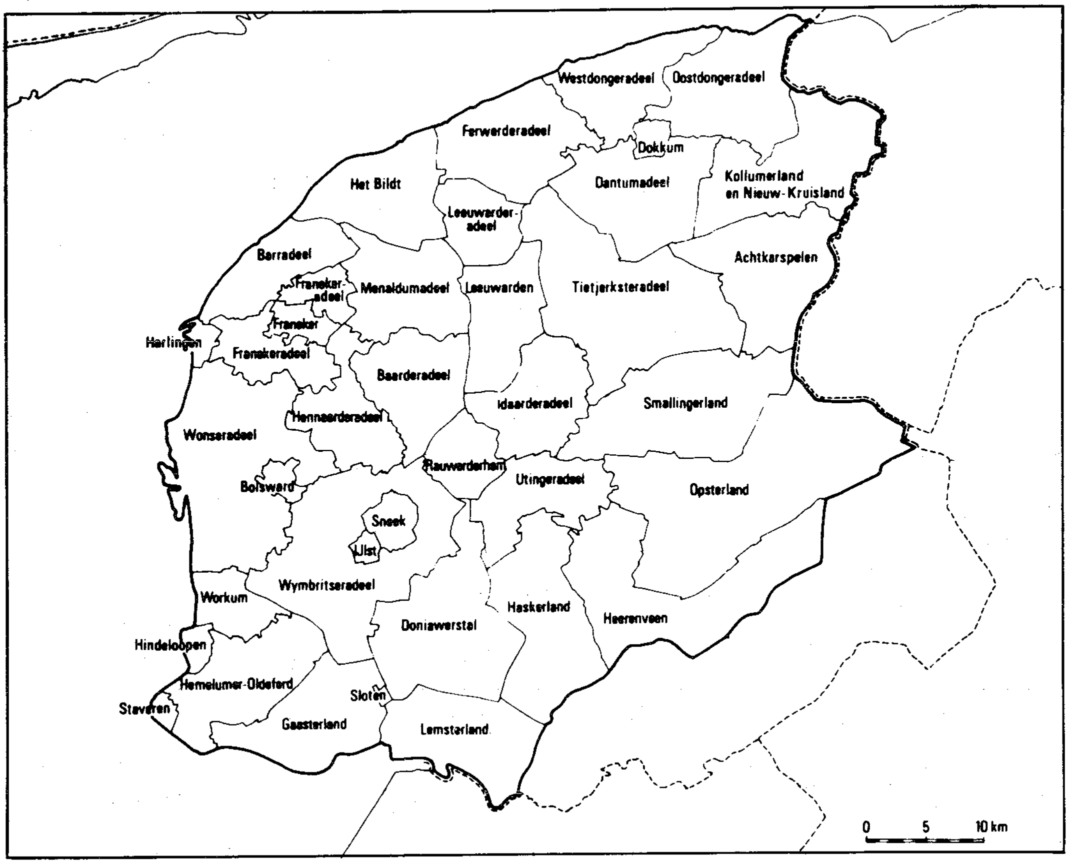

Fig. 1b. Study area Friesland.

economic structure. In contrast, the study area Midden-Gelderland is characterized by a positive migration balance. The study area covers the most important portion of one of the eastern provinces of the Netherlands, viz. Gelderland. The area may be typified as an urban area, dominated by two municipalities with over 175.000 inhabitants (Arnhem and Nijmegen), and with 39.7 percent of its population living in settlements of less than 10.000 inhabitants. In terms of observed spatial behaviour, clear and profound differences prevail between the study areas with the actual distances travelled in Friesland significantly exceeding those travelled in Midden-Gelderland.

In Friesland, 38 settlements were selected for further examination, the number of settlements examined in Midden-Gelderland was 39. Data were collected by personal interviews. The target number of interviews was 100 for each municipality, except for the three largest municipalities where 400 households were interviewed. The sample in Friesland thus contained 38 settlements and 4 100 households. The target number of interviews in each municipality was obtained by a random sampling procedure. Examination of the responses indicated that the households in both study areas visited a number of settlements outside the study areas. These settlements were also included in the final analysis, yielding 55 destinations in Friesland and 49 destinations in Midden-Gelderland.

Method and results

The empirical part of this study strictly followed the methodology developed by Rushton (1969b) for scaling spatial objects. This methodology is based upon the premise that individuals reveal their preferences in the act of choosing a particular spatial alternative. This implies that preference functions may be derived from observed spatial choice patterns. The underlying assumptions is that an individual reveals his preference for the alternative he patronizes. By making pairwise comparisons, a preference scale describing a rank ordering of the spatial alternatives can be constructed.

Rushton's methodology involves that the spatial alternatives are described in terms of abstract properties. Each spatial alternative is defined as a combination of distance-separation between the individual's residence and the location of the alternative and a measure of the attractiveness of the alternative. The construction of these so-called 'locational types' is guided by two somewhat contradicting considerations. In order to minimize the heterogeneity within each locational type, it is desirable that the locational types encompass only as few spatial alternatives as possible. On the other hand, such a decision would probably imply that not all locational types are pairwise compared in reality which, in turn, might lead to degenerative scaling solutions. Consequently, the definition of the locational types deserves careful consideration and experimentation.

In the present study, locational types were defined as combinations of distance-separations and functional complexity. Distance-separation is considered to be a negative stimulus on the individual's choice process. Functional complexity is a measure of attractiveness of the shopping alternatives. It is assumed that it represents a positive stimulus on the individual's choice process. The locational types used are shown in Figure 2. Four distance categories were identified, each category representing fifteen kilometers. The choice of the categories was based upon the condition that the two main municipalities in Midden-Gelderland should be placed in the first respectively second distance category for consumers living in the area between these two municipalities. The functional complexity of the municipalities was adapted from a study on the identification of a functional hierarchy of central places (RPD 1974). Four strata were identified. These strata were identified on the basis of the number of establishments in a variety of functions using Davies' functional

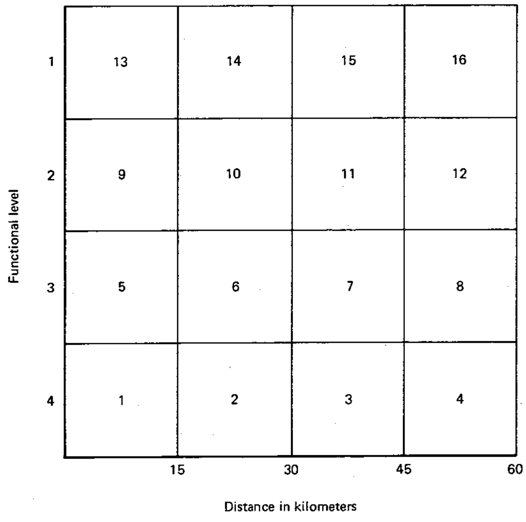

Fig. 2. The locational types.

index method and elementary linkage analysis. In total, sixteen locational types were used for further analysis.

Having defined the shopping alternatives—municipalities—in terms of these two abstract properties, it is possible to determine the relative frequency with which one locational type is chosen when both locational types are present. If consumer choice behaviour is considered to be a pairwise comparison between the locational types, data on shopping patterns can be used to construct this matrix of relative frequencies. Using the REVPREF-algorithm (Kern and Rushton 1969) and the shopping patterns of 4100 households in Friesland and 4500 households in Midden-Gelderland as input data, the matrix of relative frequencies was computed for Friesland as well as Midden-Gelderland. Given such a matrix, it is possible to derive a rank ordering of the locational types describing the percentage of times one locational type is prefered to other locational types. The results of this analysis are given in Table 1.

Table 1 clearly illustrates that the rank ordering of the locational types in Midden-Gelderland is very similar to the rank ordering of the locational types in Friesland. Only from the eleventh order some clear differences exist between the study areas. If, however, we eliminate locational types 2, 3, 4 and 8 in Midden-Gelderland and locational type 12 in Friesland, which were never chosen probably due to the spatial structure of

Table 1. The rank ordering of the locational types

Rank-order	Midden-Gelderland Locational Type	Friesland Locational Type
1	13	13
2	9	9
3	14	14
4	5	1
5	1	15
6	15	5
7	10	10
8	16	16
9	6	6
10	11	11
11	7	2
12	12	7
13	8*	3
14	4*	8
15	3*	4
16	2*	12*

* = Never chosen

Table 2. The preference scale

Locational type	Midden-Gelderland Scale Value	Friesland Scale Value
13	+ 1.000	+ 1.000
9	+ 0.653	+ 0.807
14	+ 0.587	+ 0.679
5	+ 0.517	+ 0.485
1	+ 0.241	+ 0.385
15	+ 0.136	+ 0.349
10	− 0.202	+ 0.241
16	− 0.064	+ 0.021
6	− 0.304	− 0.090
11	− 0.553	− 0.197
2	–	− 0.437
7	− 0.884	− 0.538
3	–	− 0.704
8	–	− 0.837
4	–	− 1.000
12	− 1.000	–
Stress	0.094	0.069

the study areas, the correspondence between the rank orderings of the locational types in the two study areas is nearly perfect, the only difference being an interchange of locational types 5, 1 and 15. This result might indicate that the differences in observed spatial shopping behaviour between the two study areas are the result of differences in spatial structure rather than the result of differences in underlying preferences of consumers.

This contention is further enhanced if it can be shown that there exists a close resemblance between the preference scales for the study areas, which can be derived from the matrices of relative frequencies. The relative frequencies may be interpreted as the probability that one locational type will be chosen when both locational types are present. Hence, the absolute value of the difference of the relative frequencies from .5 gives a matrix, showing the perceived dissimilarities between the locational types. This matrix serves as input to a non-metric multidimensional scaling algorithm, the purpose of which is to derive a unidimensional preference scale on which the locational types are positioned. The scale is derived in such a way that the ordinal relationships in the matrix of perceived dissimilarities are preserved as closely as possible in terms of inter-point distances on the preference scale (see e. g. Golledge and Rushton 1972; Kruskal, 1964). The goodness-of-fit of the preference scale is indicated by a so-called 'stress value'. A low stress-value indicates that a unidimensional preference scale gives a good description of the ordinal relationships in the proximity matrix. In addition, the transitivity of the matrix can be determined. A high value for the index of consistency indicates that the matrix is transitive. In the present study the MINISSA computer algorithm (Roskam and Lingoes 1970) was used for the derivation of the preference scales. The results are presented in table 2.

In both cases the interval scales were normalised. Table 2 confirms the assumption of unidimensional preference scales for both study areas. The stress-value for Midden-Gelderland was 0.094; the stress-value for Friesland was 0.069. In addition, the indices of consistency were satisfactory. The index of consistency for Midden-Gelderland had a value of .99993; the index of consistency for Friesland was. 99991. The goodness-of-fit of the scaling solution is further emphasized by the fact that the rank ordering of the locational types was satisfactory reproduced. In Midden-Gelderland only the rank ordering of locational types 16 and 10 was violated; in Friesland the scaling solution produced only for locational type 5 a scale value which was not in agreement with its revealed rank order. Surprisingly, however, the rank ordering of the locational types as implied by the scaling solution for Friesland was as a result of this higher scale value in closer correspondence with the rank ordering of the locational types in Mid-

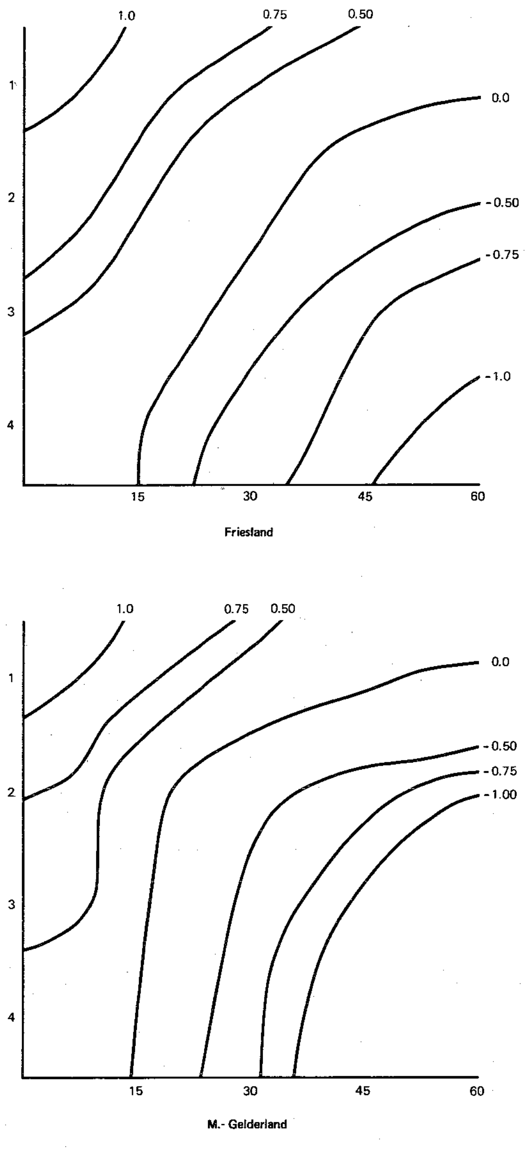

Fig. 3. The indifference surfaces.

den-Gelderland. Again, these results give rise to the conclusion that consumer spatial choice behaviour appears to be very consistent across different environmental settings. Observed differences in aggregate consumer shopping patterns might be explained more fruitfully in terms of context variables, describing the spatial configuration of destinations, rather than in terms underlying differences in preferences. Revealed shopping orientations were shown to be related to relatively invariant preference structures.

Another way of comparing the spatial behaviour in the study areas is to construct an indifference surface of revealed spatial behaviour. The isolines of the indifference surfaces portray all combinations of stimuli, that is, all locational types, which are similar in preference. Consumers are indifferent as to combinations of stimuli along each isoline. The scale values derived by the MINISSA algorithm were used to construct the indifference surfaces for Friesland and Midden-Gelderland. The results are portrayed in Figure 3.

Figure 3 shows that the indifference surfaces are very similar, although it also clearly illustrates that consumers in Friesland patronize lower order places at relatively great distances whereas consumers in Midden-Gelderland do not visit these locational types. This result tentatively suggests that the smaller central places in Friesland are more functionally complementary than the smaller central places in Midden-Gelderland, although the result might also be explained in terms of differences in locational patterns between the study areas. Evidently then, this research finding warrants further empirical investigation. In addition, Figure 3 clearly illustrates that, at all distances, the preferences of consumers are monotonically related to the functional complexity of locational types. The effect of functional complexity is made clearer in Figure 4. It demonstrates that the relationship between preference and functional complexity is one in which preference decreases with increasing distance. This is also clearly shown in Figure 5. Finally, Figure 3 reveals that consumers in both study areas tend to substitute relatively good distance for bad functional complexity and relatively good functional complexity for poor distance.

Predictive ability of preference structures

If the revealed preference approach is to contribute to the evaluation of environmental planning programs, it has to be shown that preference functions calibrated in one study area can be used to predict spatial consumer behaviour in different areas with a completely different configuration of destinations. If it can be demonstrated that this transferability exists, the revealed

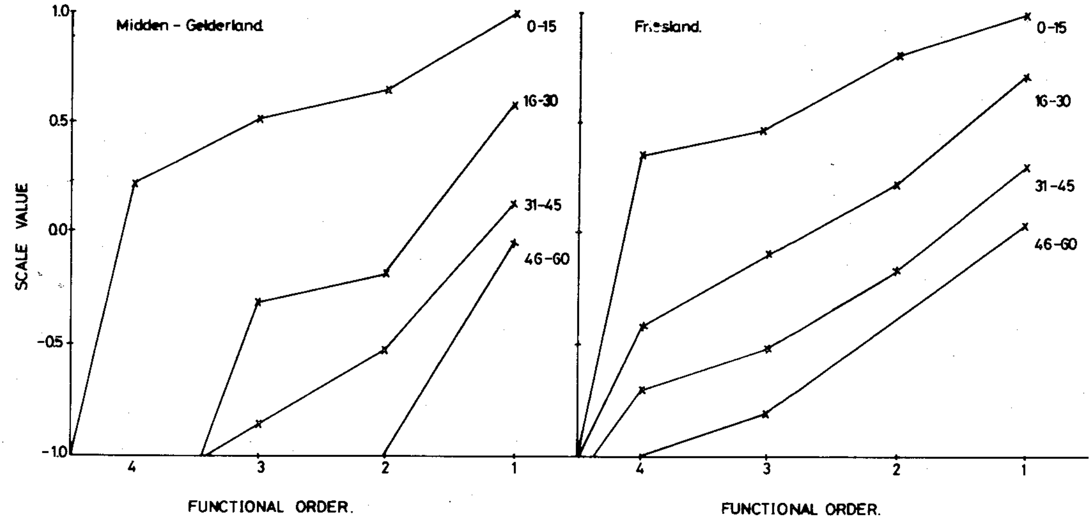

Fig. 4. The effect of functional order on preference scale values.

preference approach must be considered as superior to the traditional gravity and entropy-maximizing models, whose parameters are dependent upon the geometry of the study area and which can, strictly speaking, therefore not be used to predict the effect of changes in the retailing environment on consumer behaviour (Veldhuisen and Timmermans, 1979). Evidently, the underlying assumption of the revealed preference approach is that consumers have developed an invariant preference function which is applied in any environmental setting. Rushton's methodology is, at least in theory, relatively independent of the frequency with which the spatial alternatives occur, if it is accepted that consumer choice behaviour can be considered as a

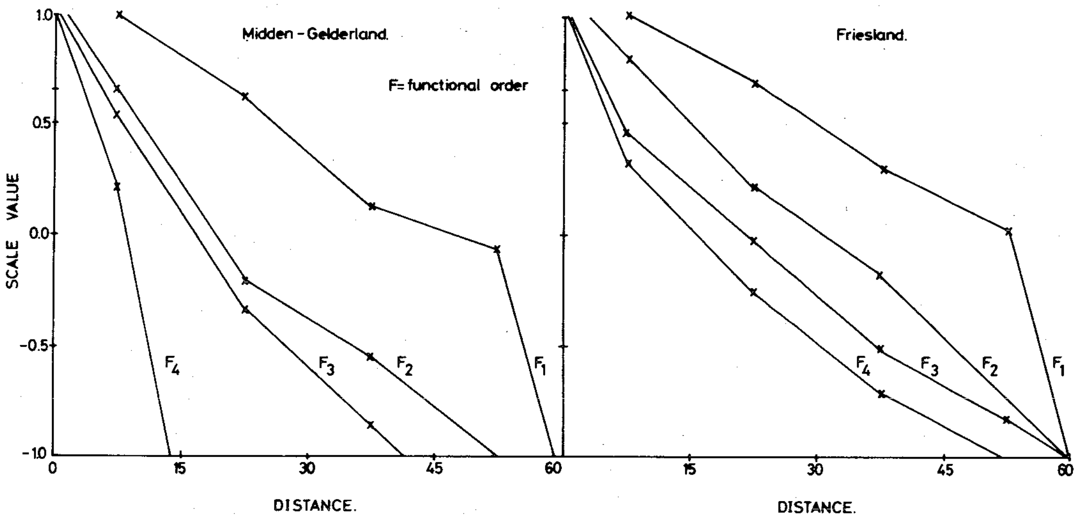

Fig. 5. The effects of distance on preferences scale values.

pairwise comparison between locational types. The idea of transferability therefore appears to await only empirical evidence.

In order to test the hypothesis that preference functions calibrated on data pertaining to one study area can be used to predict aggregate shopping patterns in another area, a choice rule relating preference scale values to probabilities of choice has to be implemented. The most simple rule is the deterministic choice rule. It implies that consumers will always patronize the locational type which scores best on their preference function. While this rule has been employed successfully in previous studies (Bell, 1973; Timmermans, 1979), it presupposes that all consumers will have identical preferences. Acknowledgment of the fact that consumers will not have identical preferences requires the formulation of a probabilistic choice rule to convert distances on the derived preference scale into pairwise choice probabilities. Following Girt (1976), whose method has been based upon Luce's choice model (Luce, 1959), it is assumed that the functional relationship between differences in preference scale values and pairwise choice probabilities is linear. Essentially then, the method involves minimizing the function:

$$\Sigma \left[\frac{D\,(x,\,y)}{\beta} - \delta\,(x,\,y)\right]^2 \qquad (1)$$

subject to: if $D\,(x,y) \geqslant \beta/2$, $D\,(x,y) = \beta/2$

where $D\,(x,y)$ = the distance between locational types x and y on the preference scale;

$\delta\,(x,y)$ = the perceived dissimilarity between locational types x and y : $p\,(x,y) - 0.5$, where $p\,(x,y)$ is the probability that y will be chosen to x;

β = a convertion factor.

The estimation of the pairwise choice probabilities p (x, y) is then straightforward:

$$p^*\,(x,\,y) = \begin{cases} 0.5 \text{ if } D\,(x,\,y) = 0 \\ 0.5 + D\,(x,\,y)/\beta \text{ otherwise} \end{cases} \qquad (2)$$

The probability that a particular locational type will be chosen from among the total set of available locational types (S) is estimated by means of Luce's choice model:

$$p^*\,(x,\,S) = \frac{1}{1 + \sum\limits_{\substack{y \varepsilon S \\ x \neq y}} \left\{\frac{p^*\,(y,\,x)}{p^*\,(x,\,y)}\right\}} \qquad (3)$$

If some locational type is available more than once it can be included as many times as it occurs in the study area.

Given this probabilistic choice rule, the predictive ability of preference structures was evaluated using the preference scale derived from the data in Friesland to predict aggregate shopping patterns in Midden-Gelderland. The parameter β in equation (1) used to convert interpoint distances on the derived preference scale into pairwise choice probabilities was 1.12 for the linear model. This implies that whenever pairs of locational types are separated at least 1.12 units on the derived preference scale, the model will predict perfect choice discrimination, that is, all consumers will show identical behaviour. The predictive ability of the preference function appeared to be satisfactory. The preference function derived from data pertaining to consumer behaviour in Friesland accounted for 96.8 percent of the variance in destination totals with regard to locational types in Midden–Gelderland. Although the ability of the preference function to predict the choice of actual municipalities in Midden-Gelderland was less satisfactory, the preference function nevertheless accounted for 94.3 percent of the variance in the total number of respondents from the sample patronizing the actual municipalities in Midden-Gelderland. The success of the approach was further illustrated by the fact that the preference function calibrated in Friesland accounted for 88.4 percent of the variance in shopping trips in Midden-Gelderland.

Conclusions and discussion

In the introductory paragraph of this paper it has been argued that behavioural geography requires solving at least two research problems if it is to contribute to the evaluation of alternative environmental planning programs. First, behavioural geography has to establish quantitatively the relationships between objective attributes of spatial alternatives, their psychological counterparts and spatial choice behaviour. Secondly, empirical evidence has to be provided supporting the claim that the results of behavioural models are independent of the spatial structure of the study area. Only recently, Rushton (1976) has tackled some aspects of the former problem in the context of his revealed preference approach. He has shown how conjoint measurement models, graphical methods and polynomial trend surface models can be used to identify the quantitative contribution to any preference scale value of objective attributes of spatial alternatives. Based upon the contention that the revealed preference approach represents a valuable way of recovering consumer preference structures (paragraph 2), the present study has addressed the latter problem. Specifically, the study has tested the idea that preference functions calibrated on data pertaining to a particular group of respondents may be used to predict the shopping behaviour of a completely different group of respondents in an entirely different environmental setting.

Comparison was made between spatial shopping patterns of respondents residing in an agricultural, lesser developed region and spatial shopping patterns of respondents located in a region dominated by the industrial and tertiary activity sector. The results of this study tend to support the claim that the preference structures are independent of the spatial structure of the study area under investigation. The space preference structure identified by the method of paired comparisons and nonmetric multidimensional scaling analysis were shown to be very similar across the two study areas. The correspondence of the rank orderings of the locational types in the two regions was nearly perfect. In addition, the general form of the indifference curves derived from the scaling solution was remarkably similar. The preference structures showed respondents to have a propensity to substitute a functionally less complex municipality at a shorter distance for a functionally more complex municipality at a farther distance. Furthermore, it turned out that the preference function derived from spatial data in one region can be used successfully to predict aggregate spatial shopping patterns in another region with entirely different environmental circumstances. It appears therefore, that consumer choice behaviour is rather consistent across different spatial choice sets and that the revealed preference approach represents a valuable way of uncovering consumer preferences. Of course, the present study has been based upon a comparison of the preference structures of only two study areas, implying that these conclusions are rather tentative. Generalization requires replication of the approach across different spatial data sets. If, however, similar results can be obtained under the same or related circumstances in different environmental settings, the recent contributions to the revealed preference approach have made it a potentially competitive or even superior approach to the traditional gravity-type models for understanding spatial shopping behaviour, at least at the regional scale.

Acknowledgement

The author is indebted to Bureau Van Heesewijk for making available the data.

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