MULTI-DIMENSIONAL PREFERENCE ANALYSIS: A REVIEW OF MODELS AND MEASUREMENT METHODOLOGY

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SUMMARY

Over the last ten years major progress has been made in the area of multidimensional preference models and related measurement and analysis procedures. This has resulted in a rich collection of models and methods that can give very valuable insights into the factors that determine consumers' preference and choices.
In this paper a review of this methodology is presented. First the theoretical roots of multidimensional preference models in economics and social psychology are briefly reviewed.
Then a taxonomy of preference models is given.
Subsequently, an examination is made of what is known about the preference models consumers actually use.
The next section deals with procedures for determining the relevant product dimensions and for obtaining perceptual maps (a condensed picture is shown in Figure 5). Then follows a taxonomy of preference measurement procedures where the characteristics of the various approaches are represented in a comprehensive scheme (Figure 6).
The last substantial section is about the relationship between preference and choice. The paper ends with a number of concluding remarks.
The main purpose of the paper is to put the various models and methods into a common reference frame, clarifying their possibilities and limitations and in this way to provide support to the researcher who has to choose his preference analysis strategy.

1. INTRODUCTION

Generally, to a consumer, a product is a multidimensional quantity. A product represents a bundle of attributes, physical (e.g. shape, colour, size, smell) as well as psychological (e.g. association with safety, health, status, prestige). In choosing a product from a set of alternatives a consumer has to compare the alternatives on the various dimensions that are relevant to him. This comparison of alternatives on the various attributes can be explicit, but most often will occur implicitly.
Multidimensional preference and choice models have been specified to describe the process by which a consumer weighs the attributes against each other and arrives at a preferred choice. Along with these models, measurement methods and analysis procedures have been developed to estimate the parameters of the models and to convert the preference information into a form that is useful for marketing decisions.

Not only has there been a great academic interest in this subject (which is illustrated by the large number of publications, especially in the second half of the seventies), but a considerable number of applications demonstrate that these models can be extremely useful for decision making in practical marketing situations, especially in the areas of product development, market segmentation and communication. See for example: Green & Srinivasan (1978), Shocker & Srinivasan (1979) and Lunn & Blackston (1978). It seems that up to now the use of this preference measurement methodology is more widespread in the U.S. than in Europe, Normile (1979).
Because of the heavy research effort a proliferation of different models, data collection procedures and estimation methods has taken place. For the researcher who wants to apply this methodology to get a better insight into what determines the purchase decisions of the consumers in his market, it is not always easy to choose the most appropriate model for his situation and to know which data collection procedure and estimation method should be used.

This paper attempts to put the various models, data collection procedures and analysis methods in a unifying framework and to clarify, in a systematic way, the major similarities and differences of the various approaches. To place these models in proper perspective, preceding the discussion of the various models, some attention is paid to the theoretical status of multidimensional preference models. Whenever possible, indications are given with respect to the appropriateness of the methods in different situations. Such indications may help the researcher in planning his research strategy.

Of course, in the context of this review, the methods cannot be dealt with in great detail. For more detail, the reader is referred to the literature references given. Although the paper starts with an elementary treatment of the various preference models, some familarity with multidimensional preference analysis will be helpful in reading the paper. A compact introductory treatment (e.g. Wierenga (1980)) might be consulted to clarify some basic concepts.
The choice situation considered in this paper is the situation where the

consumer has to choose from a set of comparable alternatives, e.g. a product (or brand) from a product category or market. For the identification of product markets procedures are given by Day et al (1979).

2. THEORETICAL FOUNDATIONS OF MULTIDIMENSIONAL CHOICE MODELS

2.1 From economics

Historically, economics was the first discipline that studied consumer behaviour. Within the framework of its axiomas (e.g. perfect knowledge of all alternatives and their characteristics, the ability of a consumer to completely rank order all alternatives) the classic theory of consumer behaviour is a "thoroughly developed branch of economic theory" (Haines 1973, p. 294).
The starting point is the utility function with respect to goods or products:

$$U = U\,(x_1,\, x_2,\, \ldots\ldots\ldots,\, x_n) \qquad (1),$$

where U = utility
x_j = the quantity bought of product j (j=1,.....,n).

With the economic theory of consumer behaviour the optimal combination of products can be derived, i.e. the combination with the highest utility given the utility function, the income level and the prices of the products. Much attention is paid to the effects of price and/or income changes on the combination of products bought by the consumer. Although for many products with a commodity character (e.g. potatoes, cheese, milk and bread) very useful demand analyses based on this classical economic theory of consumer behaviour have been carried out, this theory has less to offer when consumer choices within a product category (e.g. the choice of a specific brand of a product, a specific make of a car) have to be explained. Here the choice is made from what economists consider as essentially the same product. Only the various brands have different characteristics. With the utility function defined in terms of products, the classical economic theory has little to say about such choices.

Lancaster (1971) put forward a major extension of the theory by shifting from a utility function in terms of products to a utility function in terms of characteristics. In this approach products are conceived of bundles of characteristics (e.g. size, shape, chemical composition). The consumer is ultimately interested in these characteristics and not in the product as such. In Lancaster's theory utility is a function of the levels of the various characteristics, obtained from some goods combination x:

$$U = U\,(z_1,\, \ldots\ldots\ldots,\, z_r) \qquad (2),$$

where z_j = amount of characteristics j (j=1,.....,r) and products are related to characteristics according to:

$$z = Bx \qquad (3).$$

Here z is an r-dimensional vector of characteristics, x is an n-dimensional vector of products and B is an (rxn) "matrix of consumption technology". For example when characteristic 1 is proteins, product 1 is potatoes, b_{11} is the amount of proteins per quantity unit of potatoes.
Different from the classical theory, this characteristics approach can tell us something about the preferences for a new product (brand) in an existing product category, given that this new brand is a new combination of "old" characteristics.

In the tradition of economics, Lancaster studies the utility derived from purchasing a *combination* of different products. However, in this paper the situation of a *single* choice from a set of alternatives is studied. Ratchford (1979, p. 79-80) has shown that Lancaster's model can perfectly be adapted to this situation. He shows that in a situation with two characteristics 1 and 2 and a linear utility function, according to Lancaster's model a consumer will choose that alternative j for which:

$$U_j = w_1 b_{1j} + w_2 b_{2j} - w_3 p_j \qquad (4)$$

is maximum. Here w_1 and w_2 are the coefficients of the characteristics in the utility function, w_3 is the coefficient in the utility function for all other goods (other than the product category from which a choice has to be made), p_j is the price of alternative j and b_{1j} and b_{2j} are the amounts of characteristics 1 and 2 in alternative j. As will be seen in the next section, Eqn (4) represents one of the basic multi-dimensional choice models, i.e. the linear compensatory model. According to the notation to be used throughout the rest of the paper where y_{jt} is used to indicate the "rating" of alternative j on dimension t, Eqn (4) can be translated into:

$$U_j = w_1 y_{j1} + w_2 y_{j2} - w_3 y_{j3} \qquad (5),$$

where y_{j3} represents the "dimension" price.
Ratchford also shows that when non-linear utility functions are used, other utility models (e.g. the ideal point model) can be derived from Lancaster's model.
Notwithstanding remaining limitations, for example the assumption that characteristics are always objective measurable quantities and the complete ignoring of psychological product dimensions, Lancaster's theory is an important step forward. It can be considered as the theoretical basis in economics of the multidimensional preference models to follow.

2.2 From social psychology

In social psychology the notion that generally more than one attribute or evaluative criterion is used to evaluate a choice alternative was put forward in the form of the expectancy-value models by Rosenberg (1956) and Fishbein (1963). Although this is not the pure representation of either author's original formulation (see Engel, Blackwell & Kollat 1978, p. 394-6) the expectancy-value model can be described by the following equation:

$$A_j = \sum_{j=1}^{m} w_t B_{jt} \qquad (6),$$

where A_j = attitude toward alternative j (j=1,.....,n)
w_t = weight or importance of evaluative criterion t
B_{jt} = evaluative belief with respect to the utility of alternative j to satisfy evaluative criterion t
m = number of attributes.

Realizing that the B_{jt}'s are the ratings of the alternatives on the attributes (the y_{jt}'s in our notation) and that the attitude A_j can be conceived of in the sense of preference or utility (U_j) it is clear that Eqn (6) is mathematically equivalent to Eqn (5) which was derived from economic theory. Both equations represent a linear-compensatory model.

The expectancy-value models have received much attention in consumer behaviour research (Wilkie & Pessemier 1973). An extention has been made based on the notion that the utility is not so much dependent on the absolute level of an attribute as on the difference between the absolute level and the "ideal" level, see for example Lehman (1971). This version, the "attribute-adequacy" model can be considered as the counterpart of the ideal point models that will be encountered in the next section. Operational aspects of the expectancy-value and the attribute-adequacy model will be discussed together with the other models later on in the paper.

From the discussion in this section it can be concluded that in economics as well as in social psychology, a theoretical basis can be found for the multidimensional preference models that are the subject of this paper.

3. A TAXONOMY OF PREFERENCE MODELS

Assume that a consumer has to make a choice from n different product alternatives and that these alternatives are judged on d different attributes. Each alternative product j can then be described by a d-dimensional vector of attributes: $(y_{j1},.....,y_{jd})$. For example when the product is cars, y_1 could be: number of seats, y_2: engine power, y_3: maximum speed, y_4: price, etc.
There is one situation in which it is very easy to make a choice: when there is one alternative which on every attribute is better than or at least equal to all other alternatives. Such an alternative is called a *dominant* alternative. When for example k is the dominant alternative

Dominance		
	lexicographic model	
Noncompensatory models	conjunctive model	
	disjunctive model	
	vector model	
Compensatory models	ideal point model	additive
		distributive
	conjoint measurement model	multiplicative
		dual distributive

Figure 1. A taxonomy of preference models

this implies:

$$y_{kt} \geq y_{jt},$$

for all $j \neq k$ and $t = 1, \ldots\ldots, d$.

In the taxonomy of preference models given in Figure 1, this situation is indicated as a separate case. In fact in such a situation which is a result of the characteristics of the choice set, no preference model is required for the consumer at all.
Generally, however, one alternative is best on some attribute and a second alternative is best on some other attribute, etc. Then the consumer has to follow some strategy to arrive at a preferred choice. Figure 1 gives a taxonomy of alternative models for this strategy.

A major distinction is between *compensatory* and *noncompensatory* models. In a compensatory model a poor performance on one attribute can be made up for by a superior performance on some other attribute. In a non-compensatory model this compensation is not possible.
In Figure 1 the noncompensatory models are treated first.
In a *lexicographic* model the attributes are first listed in importance. The alternatives are then screened with respect to the most important attribute. Let this be attribute 1. Then the product is preferred that has the highest rating on attribute 1. For example, if:

$$y_{k1} > y_{j1} \qquad \text{for all } j \neq k,$$

product k would be the preferred alternative. However, in the case of ties, i.e. different products with the same high rating on the most important attribute, the second most important attribute is taken into consideration and from the set of best products on the first attribute, the product is chosen which is best on the second attribute. If ties occur again, a third attribute is used to arrive at a choice, etc. It is clear that when an alternative does not rate best on the most important attribute, this cannot be compensated by whatever supreme performance on a less important attribute. Such an alternative will never be chosen.
The *conjuntive* model specifies that a product is acceptable only if certain minimum conditions for all attributes are jointly satisfied. For example, a consumer might state that his new car should have at least 5 seats, horsepower more than 100 and maximum speed higher than 150. According to the conjunctive model the car would only be a choice candidate if number of seats ≥ 5, horsepower ≥ 100 and maximum speed ≥ 150.
In the *disjunctive* model "and" is substituted by "or". Again a consumer is assumed to set a number of conditions but now the fulfilment of each condition alone is sufficient to make a product acceptable. In the car example such a strategy would mean that a car might be bought if it either has ≥ 5 seats, or horsepower ≥ 100, or maximum speed ≥ 150. Whether this would be a realistic choice strategy may be doubted of course.

The simplest model of the compensatory type is the *vector* model, also called *linear compensatory* or *composite criterion* model. A consumer is represented by a vector, indicating the direction of his preference in the multidimensional space. In Figure 2 an illustration is given in two-dimensional space, where the preference vector of consumer i (v_i) has been drawn. The direction of v_i indicates that consumer i favours higher levels above lower levels for both attributes and that he weighs attribute 1 somewhat more than attribute 2 in determining his preference. In Figure 2 the positions of three products: A, B and C are also given. In the vector model the preference (or utility) of a product is expressed by the length of its projection on the preference vector. In Figure 2 this implies that consumer i prefers A to B and B to C. The algebraic equivalent of this geometric measure is:

$$U_{ij} = v_{i1}y_{j1} + v_{i2}y_{j2} + \dots\dots\dots \; v_{id}y_{jd} \qquad (7),$$

where U_{ij} is the utility of alternative j for consumer i. Eqn (7) clarifies the name "linear compensatory" model. The expression is also equivalent to Eqns (5) and (6) encountered earlier.

The vector model just discussed is of "the more the better" type. On the other hand, in the *ideal point* model it is possible that with increasing level of an attribute the utility first increases but after a certain point starts to decrease. This is accomplished by the notion of an ideal point. The utility of a product decreases with increasing distance from the ideal point. In the two-dimensional illustration in Figure 3 consumer i has an ideal point of I_i.
Because of the order in distances consumer i prefers C to A and A to B. It is possible in the ideal point model to have different weight factors for different dimensions. The algebraic expression for the general ideal point model is:

$$U_{ij} = \{-w_1(y_{j1}-I_{i1})^2 \; -w_2(y_{j2}-I_{i2})^2 \dots\dots \; -w_d(y_{jd}-I_{id})^2\}^{\frac{1}{2}} \qquad (8),$$

where U_{ij} = utility of product j for consumer i. The negative signs of the w's stem from the fact that the utility is lower the greater the distances. If so desired, it is always possible to make the utility positive by adding an arbitrary positive constant to the right-hand-side of Eqn (8).

In the *conjoint measurement* model there is a separate utility function (= part-worth function) for each attribute. The overall utility is a combination of these part-worth utilities.
The part-worth function for product j on attribute t can be given as:

$$U_t = U_t(y_{jt})$$

and in the additive conjoint measurement model the overall utility of product j is:

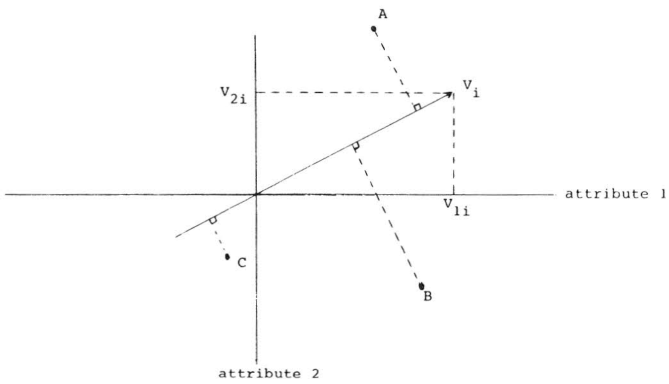

Figure 2. Illustration of the vector model

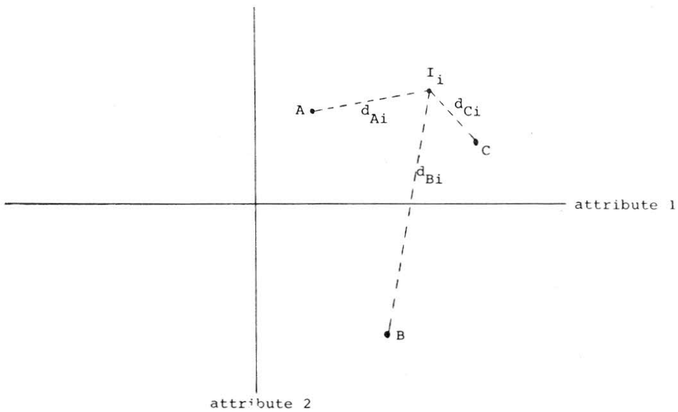

Figure 3. Illustration of the ideal point model

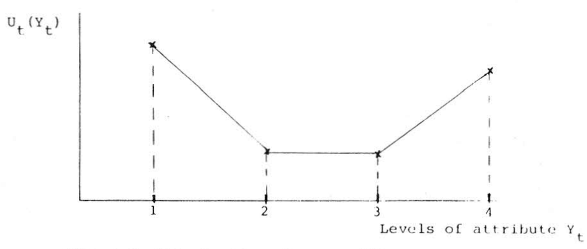

Figure 4. Illustration of a possible part-worth function

$$U_j = U_1(y_{j1}) + U_2(y_{j2}) + \dots\dots\dots + U_d(y_{jd})$$ [1)]

In the conjoint measurement model the attributes are not continuous, but a number of discrete levels are distinguished for each attribute. For example in Figure 4 four attribute levels are used. The part-worth functions may have all possible forms. Figure 4 describes a situation where first utility decreases with increasing levels of the attribute, then remains practically constant and subsequently increases again. Besides the additive conjoint measurement model discussed so far, models with interactive components are also possible. Three well-known forms (for convenience specified for the three attribute case) are:

the distributive model : $U_j = [U_1(y_{j1}) + U_2(y_{j2})]\ U_3(y_{j3})$ (10),

the multiplicative model : $U_j = U_1(y_{j1}) * U_2(y_{j2}) * U_3(y_{j3})$ (11),

and the dual distributive model: $U_j = U_1(y_{j1}) * U_2(y_{j2}) + U_3(y_{j3})$ (12).

Of course in Eqn (10) and Eqn (12) $U_3(y_{j3})$ can be interchanged with $U_1(y_{j1})$ and $U_2(y_{j2})$ respectively.

The three compensatory models discussed form a hierarchy where each earlier model is a special case of the following one. The vector model is a special case of the ideal point model i.e. an ideal point model with the ideal point in infinity. The ideal point model in turn is a special case of the conjoint measurement model, i.e. with parabole-like part-worth functions with their maximum at the ideal point. From vector model to ideal point model to conjoint measurement model the flexibility with respect to the form of the utility function increases (see Green & Srinivasan 1978, p. 66 for a graphical illustration of this aspect) and with this greater flexibility the number of different preference situations that can be modelled also increases. However, this greater flexibility has to be paid for by the increasing data requirements when the parameters of the model have to be estimated.

Apart from the dominance situation, in this section nine different preference models were given. Each model is a different representation of the process by which a consumer arrives at his overall preference, given the ratings of the alternatives on the various attributes. The next question then is: which models are actually used by consumers in practical choice situations and how can it be established which model is most appropriate in a given situation? This question is dealt with in the next section.

[1)] Of course it is also possible to make these utility functions idiosyncratic for individual consumers i, but because of practical data limitations, utilities used in conjoint measurement analysis are often aggregate estimates over all (or specific segments of) consumers.

4. EMPIRICAL EVIDENCE ABOUT PREFERENCE MODELS CONSUMERS ACTUALLY USE

It would be easy for the analyst if, on the basis of the empirical research reported in the literature so far, it were possible to state the conditions under which the various preferencd models could be expected to apply. However, at present, the state of knowledge with respect to consumer decision making is not sufficient to provide this kind of information. Moreover, for a number of reasons, it is doubful whether it will ever be possible to state for each specific product category unambiguously the preference model according to which consumer purchase decisions for that product are made.
(i) As can be observed, different consumers often have different preferences. This may be caused by different parameters within the same preference model (e.g. two different consumers may both use an ideal point model but with different ideal points), but it is also perfectly possible that different consumers use different preference models.
(ii) The same consumer may use different preference models in different stages of the decision process. He may use one model for making a first selection from the available alternatives and use a different model to make a choice from the remaining subset.
(iii) The model applied may depend on the circumstances under which the decision is made: time pressure, a noisy environment and other situational factors. See for an illustration Bither & Wright (1977). Also the way in which the information, needed to make a choice, is presented to the consumer may affect the preference model used, Bettman & Kakkar (1977). It is also possible that decision rules are "constructed on the spot". The analysis of Bettman & Zins (1977) suggests that this phenomenon might occur quite often.

Therefore, it cannot be expected that with a specific preference model a very precise description can be obtained of the actual decision processes occurring in the minds of the consumers in a particular market. At best a model will be an approximation of these decision processes. This does not preclude the possibility of obtaining good predictions of brand chioice with such an approximating model, however.
A case in point is the model of Bernardo & Blin (1977). They described the consumer decision process by a linear programming algorithm (which it obviously is not), but received very reasonable predictions of actual purchases.
Nevertheless, even if a perfect model remains a utopia, it will always be necessary to search for the model that is the closest approximation of the actual decision process.

Up to now most work in consumer preference modelling has used compensatory models. Within the category of compensatory models it is - at least in principle - relatively easy to test which functional form (e.g. vector model, ideal point model or some conjoint measurement specification) is most appropriate in a given situation. Here, the hierarchy notion, referred to earlier, can be used. For each given model it can be tested whether or not a richer, more general model would provide a more adequate fit to the data. It is much more

difficult to determine whether either a compensatory or a noncompensatory model is the most adequate representation of the actual choice strategy. Different research modes can be applied to study this question. It is possible to have a sample of respondents to make choices from a set of carefully defined product alternatives in a simulated situation and examine which model gives the best prediction of the choices actually made. Pras & Summers (1975) and Park (1978) use this approach.
Another research device is to observe real purchasing situations of consumers and have all the conversations made by the respondent (with the interviewer and with other consumers) recorded on a tape recorder. It is also possible to ask the respondents to think aloud about their purchase decisions (and to have this recorded as well). Attempts could then be made to deduce the nature of the choice strategy from such protocols. Examples of this methodology are Bettman & Zins (1977) and Lussier & Olshavsky (1979).
A third research methodology (Van Raaij 1976) is the use of an information display board containing information about the choice alternatives on a number of attributes. By studying the order in which the various information elements are searched, some insight into the choice model used by the respondent can be obtained. For example, in a lexicographic model, search by attribute (i.e. subsequently considering different alternatives on the same attribute) is expected, whereas in a compensatory model search by alternative (i.e. where subsequently various attributes of the same alternative are considered) will be dominant.

As indicated, general conclusions from the research so far are scarce, but several researchers seem to agree on the following. The choice process can be considered as a two-stage process where, in the first stage, some noncompensatory rule (e.g. lexicographic or conjunctive) is used to arrive at a set of acceptable alternatives. In the second stage, some compensatory model is applied to arrive at a choice from this remaining set of alternatives. This notion of a two-stage process can be found in Pras & Summer (1975), Park (1978), Green & Srinivasan (1978, p. 118), Van Raaij (1976) and Lussier & Olshavsky (1979). The set of alternatives from which the ultimate choice is made, can be imagined as the evoked set, as defined by Howard & Sheth (1969). So the use of compensatory models seem to be justified as far as the choice set considered contains only alternatives belonging to the evoked set of the respondent.
Of the compensatory models the most simplest form: the linear compensatory model has been applied most. It can be observed (Green & Srinivasan 1978, p. 107) that in many preference situations the conditions are met under which this model constitutes at least a good approximation to the decision process. The whole tradition of expectancy-value models (see section 2) is based on the linear compensatory model. The conjoint measurement model can also be considered as a linear compensatory model where the explanatory variables (corresponding with the various levels of the attributes) are 1-0 variables.

5. FINDING THE RELEVANT PRODUCT DIMENSIONS

When a multidimensional preference model is to be applied in a specific product market, the researcher has to know the dimensions by which the alternatives are judged by consumers (= the relevant dimensions) and how each alternative is perceived on each of these dimensions.
A broad selection of different methods is available to carry out this kind of analysis. A taxonomy is given in Figure 5. The text will follow this scheme.

A first distinction is between decompositional and compositional methods. The *decompositional* methods start with the overall image and use data (similarity ratings) in which no reference is made to any specific attribute. Attempts to "decompose" this image into the underlying perceptual dimensions are made by means of multidimensional scaling. As indicated in Figure 5, in multidimensional scaling different procedures can be used for the collection of data. For details the literature references should be consulted. Algorithms[1)] can be used that produce either an homogeneous perceptual configuration or perceptual configurations that allow differences among consumers. In the first case, analytical methods can be used to rotate the configuration and to interpret the results. The ultimate output is a perceptual map of the products in a multidimensional space, often of two to four dimensions.
A recent monograph by Kruskal & Wish (1978) gives, in less than 100 pages, a very clear and non-technical treatment of this type of multidimensional similarity scaling.

In the second category of methods, *compositional* methods, the image (perception) of a product is - so to speak - built up ("composed") from the ratings of the product on a number of different scores. Since the number of imaginable attributes is almost infinite some pre-selection has to be done.
In a compositional analysis it may or may not be desired to arrive at a perceptual map in a space of reduced dimensionality.
In the Fishbein-type models (expectancy-value and attribute-adequacy models), the ratings on the attribute are used directly; no reduction in dimensions is carried out. Here the attribute ratings have the character of evaluative beliefs. For example scales are used like:

this package is:	very attractive ..... very unattractive
the taste of this product is:	very good .... very bad.

Procedures for arriving at a perceptual map in a reduced space make use of the dependency among attributes. Factor analysis starts with a correlation matrix of the attributes obtained by pooling over respondents and choice alternatives. Multiple discriminant analysis uses as dependent

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1) In Figures 5 and 6 computer algorithms (e.g. INDSCAL) are indicated by capitals. For each algorithm a reference is given. The algorithms mentioned are indicative; often different algorithms (not mentioned here) exist that perform the same computations.

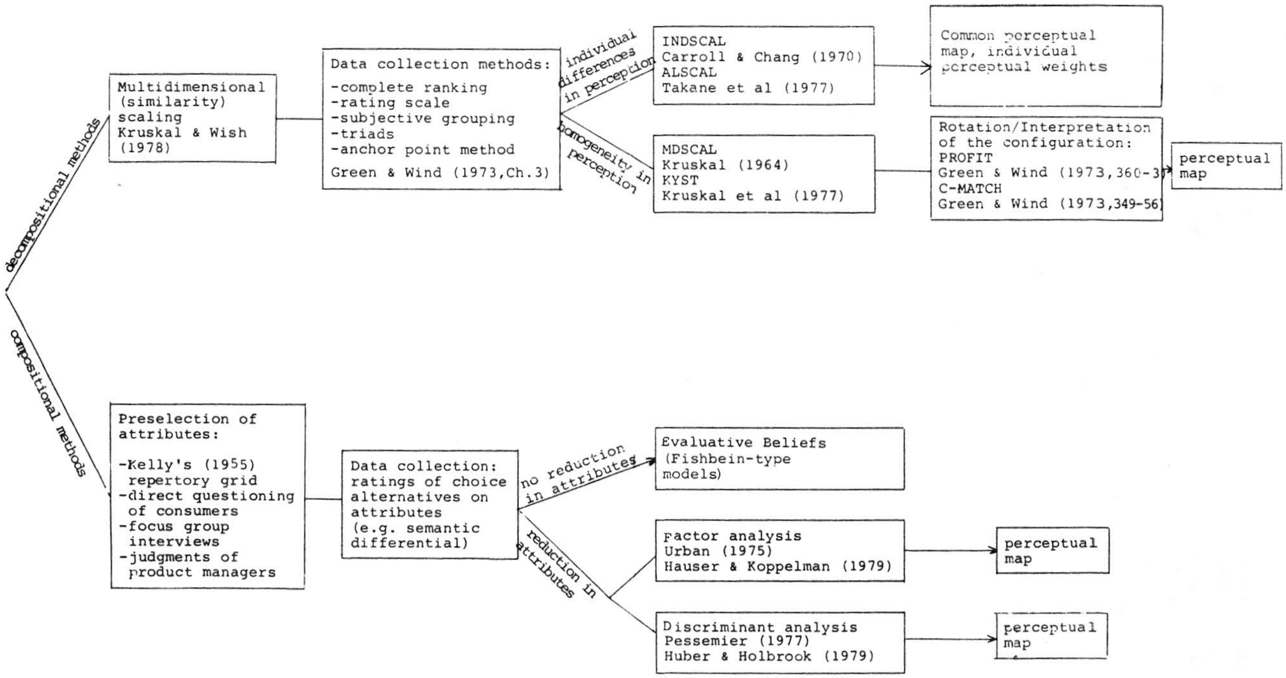

Figure 5. A taxonomy of methods for finding the relevant product dimensions

measure (the class) the product rated and as explanatory variables the attribute ratings. A separate perceptual map is obtained for each respondent both with factor analysis and discriminant analysis. The centroid of these maps can be considered as the common perceptual map.

Considerations when choosing a particular method

A major choice is between an analysis of the Fishbein-type (e.g. with the expectancy-value model) or by one of the dimensions-reducing methods (similarity scaling, factor analysis, discriminant analysis). In the expectancy value approach the emphasis is on consumers' feelings: affective judgments with respect to the products, whereas the dimensions-reducing models aim at obtaining perceptual maps representing cognitive aspects. A major consideration is the purpose of the analysis. If the result of the analysis is to be used for the formulation of an advertising strategy, information about the affective aspects may be very important. If the purpose of the analysis is to find opportunities for new products in the multidimensional space, working from a perceptual map of low dimensionality is very convenient. Generally, the perceived dimensions are more "actionable" (Shocker & Srinivasan 1974) than the affective dimensions of the Fishbein model.

With respect to a choice from the various dimensions-reducing methods a first consideration is the number of different choice alternatives. To get reliable results with multidimensional scaling the number of products should be at least 7 or 8 (Klahr 1970). For the compositional methods there is no such limitation. On the other hand multidimensional scaling is a non-metric method which allows the data to be ordinal. Moreover, with a compositional method one will only find dimensions derived from the attributes first included in the analysis, so if a major property is left out from the beginning, it will never show up again. Another aspect of compositional methods is the difficulty in isolating the pure perceptual dimensions. Often the attribute ratings contain some underlying good-bad dimension. (This is in fact a fundamental characteristic of the semantic differential.) Holbrook & Huber (1979) present a methodology to separate these "affective overtones" from the perceptual judgments. In a study where three methods for perceptual mapping: similarity scaling, factor analysis and discriminant analysis were compared, Hauser & Koppelman (1979) found that perceptual maps obtained from factor analysis gave the best results in preference prediction.
Comparing factor analysis and discriminant analysis, Huber & Holbrook (1979) show that factor analysis tends to orient a space to dimensions that have high variance both within and between products, whereas discriminant analysis orients a space to those dimensions that have high variance across products but low variance for subjects rating a given object. Generally, factor analysis and discriminant analysis will not produce the same perceptual map.

In practical situations probably the best strategy is to collect similarity data as well as attribute ratings. Then the results of different analysis methods can be compared. The attribute ratings are also useful for the decompositional analysis: these ratings can serve as "external variables" in the analytical procedures (PROFIT, C-MATCH) to improve the interpretation of the multidimensional scaling configuration obtained.

6. METHODS FOR PREFERENCE ANALYSIS

After having determined the relevant product dimensions and the positions of the choice alternatives on these dimensions, the next question is how consumers combine these ratings into overall preference scores. Figure 6 gives a taxonomy of methods that can be used to study this question. The various methods given all refer to compensatory preference models (section 4 discussed the conditions when compensatory models are applicable).
It is not possible to give a comprehensive treatment of all methods of preference measurement here. The most important information is contained in Figure 6. In this text a number of remarks will be made with reference to this scheme.

An important distinction is between (i) methods that infer preference parameters from preference statements made by respondents (e.g. from stated preference orderings with respect to a set of alternatives) and (ii) methods that obtain preference parameters by direct questioning of consumers (= direct scaling).
The methods in the first category are for a major part developed in the area of psychometrics and data theory, the methods of the second category are in the cognitive consistency tradition (Fishbein).
In the first category one can choose between inernal and external analysis.
In the case of *internal* analysis the input data does not include a perceptual configuration of products, this configuration is part of the output of the analysis. In general, internal analysis, especially in the case of the ideal point model, makes high demands upon the data. A large number of parameters has to be estimated from the preference information only. Of course, as more specific assumptions are made with respect to the preference function, better results can be expected. This is demonstrated by Moore et al (1979), who used the Schönemann-Wang model.

With *external* analysis a configuration of products in a multidimensional space (which may have been obtained in an analysis as described in the last section) is an input element for the analysis.
With respect to the differences between LINMAP and PREFMAP, which are both applicable in the case of the vector model as well as the ideal point model, LINMAP has the advantage of being a strict non-metric procedure, whereas PREFMAP is essentially a metric (regression) procedure. Furthermore, with LINMAP it is possible to estimate a "mixed" model, i.e. a preference model that is of the ideal point type on some dimersion(s) and of the vector type on other dimensions.
Both LINMAP and PREFMAP can be applied to an ideal point model with

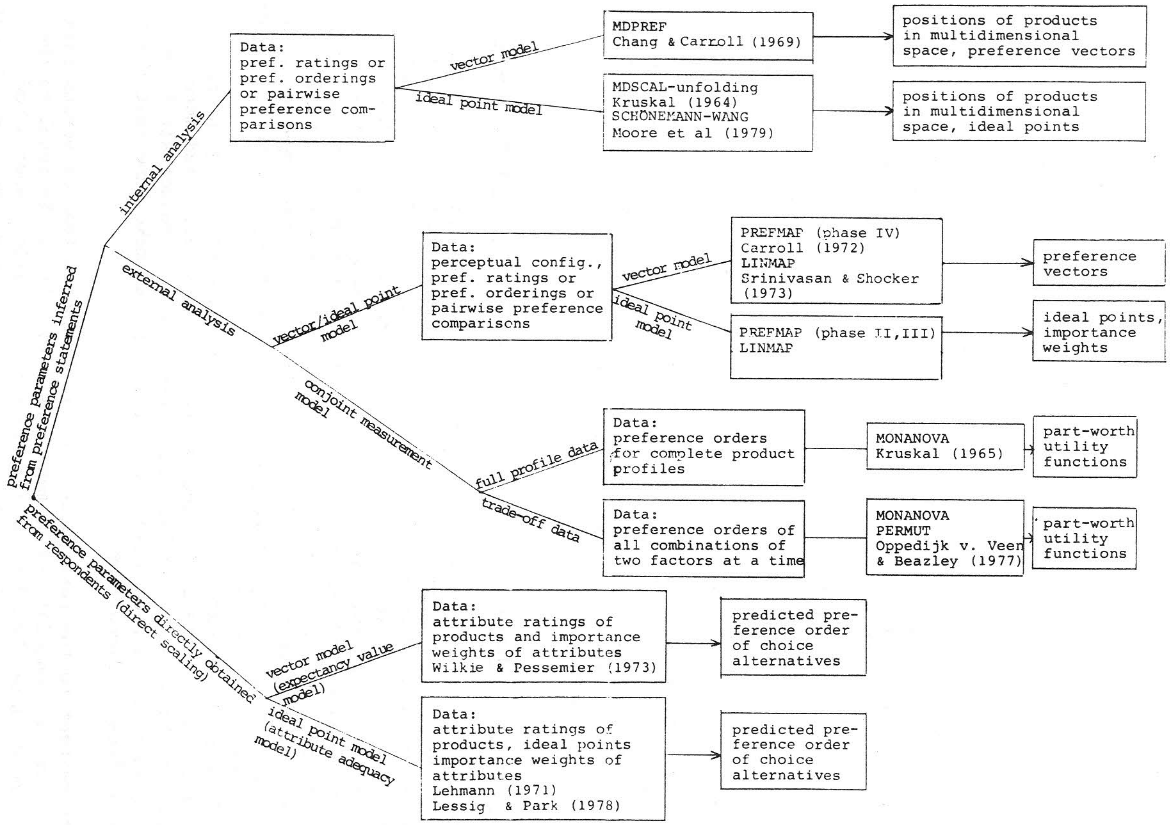

Figure 6. A taxonomy of methods for preference analysis

weights (the w_j's in Eqn (8)), but PREFMAP easily produces negative ideal points which are difficult to interpret.

When estimating parameters of the conjoint measurement model either full-profile or trade-off data can be used. With *full-profile* data the respondent has to take into account the levels of *all* attributes when making his preference judgments. With *trade-off* data he only has to compare different combinations of attribute levels of *two* attributes at a time. From the reported results no general conclusion can be drawn so far as to which approach should be preferred (Green & Srinivasan 1978). In the case of the additive model Kruskal's MONANOVA can be used (for trade-off data also specific procedures e.g. PERMUT are available). After defining the different levels of the attributes in terms of 0-1 it is possible to use PREFMAP and LINMAP for conjoint measurement. It is also possible to define interaction terms as 0-1 variables and in this way to estimate the more complex conjoint measurement models (Eqns (10)-(12)).
For the models in the "Fishbein"-tradition the parameters are directly obtained from respondents. These parameters include: ratings of the products on the attributes (e.g. using semantic differential scales - see last section -), importance weights of the attributes (e.g. using constant sum scales) and - in the case of the attribute-adequacy model - the explicit ideal ratings on the attributes. In the latter model the attitude is a function of the difference between the absolute rating and the ideal rating. So far, however, the superiority of this attribute-adequacy model as compared with the expectancy-value model has nog been convincingly demonstrated (Wilkie & Pessemier 1973, p. 435, Lessig & Park 1978).

Considerations when choosing a particular method for preference analysis

Methods that obtain preference parameters directly from respondents (i.e. the Fishbein-approach) can provide valuable insight into the evaluative beliefs which lie behind the preference judgments. This information may be very useful, for example in advertising. However, as already mentioned, for many purposes, for example the development of new products and market segmentation the distribution of consumer preferences over the (reduced) product space and the relationship between product characteristics and preferences is very important. For this purpose the first category of analysis methods, as given in Figure 6, is more appropriate.
Of these methods, external analysis has the advantage over internal analysis in that the preference parameters can be estimated more accurately and the researcher can determine which product attributes are used to explain consumer preferences. He can make sure that these are actionable dimensions.

With respect to the particular model to be chosen (vector versus ideal point versus conjoint measurement model) the fit of the model to the preference data should be an important consideration. When a model gives a good fit, it should be considered whether a simpler model could

also do the job; with a bad fit it should be considered whether a more general model would be an improvement. In the PREFMAP-framework formal statistical tests (F-tests) can be applied. One aspect of the conjoint measurement method is that in most applications it is not possible to work with existing real products but artificial product profiles have to be defined.
A number of further considerations which should be taken into account when choosing a preference analysis method, e.g. with respect to data requirements and particular algorithms were discussed in the first part of this section.

7. FROM PREFERENCE TO CHOICE

The models discussed in the last section are *preference* models, relating consumer preferences to product dimensions by putting both, products and consumers, in an abstract multidimensional space. For some applications this abstract representation as such offers enough insight, but in many cases the step from preferences to *choice* is also interesting.
When the results from a preference analysis are to be used to find "promising positions" for new products in the multidimensional space, i.e. new attribute combinations that will be bought by sufficient consumers, two additional issues have to be dealt with.
(i) How are preferences related to choice probabilities?
(ii) Which procedures can be used to find promising points in the multidimensional space?

With respect to (i) the simplest model is the single choice model, which implies that a consumer chooses the product of his highest preference. For example, in the case of the ideal point model this would imply that the product with the shortest distance to the ideal point is actually chosen.
Since generally different consumers have different preference parameters the product with the highest preference will be different from person to person. Notwithstanding its simplicity the practical result with this single choice model has been quite satisfactory, Nakanishi et al (1974), Braun & Srinivasan (1975), Parker & Srinivasan (1976), Wierenga (1978).
In more sophisticated models preference is related to choice probability in such a way that a higher preference implies a larger choice probability, but products with a lower preference also have a positive (perhaps small) probability to be chosen. On the level of the individual consumer this seems a more realistic model than the single choice model.
Urban (1975) uses a linear function for the relationship between preferences (as measured by the squared distance from the ideal point) and choice probability.
Shocker & Srinivasan (1974) specify:

$$\Pi_j = \frac{a}{d_j^{\,b}} ,$$

where Π_j = choice probability of product j
d_j = distance of product j from the ideal point,

and a and b are parameters.

Moore et al (1979) use the relationship:

$$a_j = e^{-cd_j^2} ,$$

where a_j is the preference scale value of product j.
In their model the preference scale values are related to choice probabilities by the so-called Bradley-Terry-Luce model:

$$\Pi_j = \frac{a_j}{\sum_{i=1}^{n} a_i} .$$

Also a multinominal logit model (McFadden 1970) can be used to relate preferences to choice. A logit model makes specific assumptions about the error term in the choice equation. An illustrative application is Punj & Staelin (1978). The logit model can also be applied directly to relate product attributes and product choice (i.e. without first carrying out a preference analysis as described in the last section). However, because of the limited information obtained from individual respondents (mostly the actual choice only) this type of analysis has to be carried out on aggregate data, so that homogeneity with respect to preference parameters within the consumer population has to be assumed.

With respect to (ii): procedures to find promising positions in the multidimensional space, the most straightforward (and probably most used) approach is to perform choice simulations for hypothetical new product concepts. The new (hypothetical) product is placed in the multidimensional space, for each respondent the preference is computed for the new and the existing products (using the preference parameters estimated earlier), the preferences are converted into choice probabilities (using one of the models just discussed) and the expected market shares for the new brand as well as for the existing brands can be computed. Wierenga (1978) gives an example of this approach. In this procedure it is possible to see from which of the existing brands the new brand gets its market share.
Such choice simulations can be done if a company has several alternative well-defined new product concepts from which one is to be chosen. When there are no such clear-out candidates the product space may be searched for opportunities. Albers & Brockhoff (1977) and Albers (1979) developed an analytical procedure using mixed integer nonlinear programming to carry out this search. Shocker & Srinivasan (1974) recommend heuristic

procedures (gradient search and grid methods) to find good product opportunities. Pessemier (1977) also uses an heuristic procedure. A characteristic of these less-sophisticated procedures is that it is possible to obtain more decision-relevant information (e.g. they give incremental profit of adding the new product to the product line instead of only sales of the new product) than with the advanced non-linear programming methods. It should also be realized that the latter methods can easily come up with products that are not technically or economically possible. These analytical procedures, either looking for the global optimum or heuristic, can be of major help in searching the product space for new opportunities.

8. CONCLUDING REMARKS

In the field of multidimensional preference models and analysis methods major progress has been made during the last ten years. This has resulted in a set of tools that significantly increase our ability to gain insight into the factors that determine consumer preferences and choices. This type of information is very useful for marketing decision making: product development, market segmentation, communication and pricing.
The user of this preference analysis methodology can choose from a great diversity of methods. To utilize the full potential of this approach he should be able to judge the major possibilities and limitations of the various measurement and analysis procedures.
This paper presented a systematic review of these methods. Emphasis was placed on operational aspects: what kind of results can be obtained and under which conditions are the different methods appropriate?
It is hoped that this information will be useful to the researcher who wants to apply this methodology and that it will further increase the benefits obtained from these new research tools.

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