Basic concepts in multidimensional scaling (MDS)

Multidimensional Scaling (MDS) is a class of procedures for representing perception and preferences of respondents spatially by means of a visual display. Perceived or psychological relationships among points in a multidimensional space. These geometric representations are often called spatial maps. The axes of the spatial map are assumed to denote the psychological bases or underlying dimensions respondents use to form perceptions and preferences for stimuli. MDS has been used in marketing to identify:

1. The number and nature of dimensions consumers use to perceive different brands in the marketplace
2. The positioning of current brands on these dimensions
3. The positioning of consumers ideal brand on these dimensions

Information by MDS has been used for a variety of marketing applications, including:

- **Image measurement**. Compare the customers' and noncustomers' perceptions of the firm with the firm's perceptions of itself and thus identify perceptual gaps.
- **Market segmentation**. Position brands and consumers in the same space and thus identify groups of consumers with relatively homogeneous perceptions.
- **New product development**. To look for gaps in the spatial map, which indicate potential opportunities for positioning new products. Also, to evaluate new product concepts and existing brands on attest basis to determine how consumers perceive the new concepts. The proportion of preferences for each new product is one indicator of its success.
- **Assessing advertising effectiveness**. Spatial maps can be used to determine whether advertising has been successful in achieving the desired brand positioning.
- **Pricing analysis**. Spatial maps developed with and without pricing information can be compared to determine the impact of pricing.
- **Channel decisions**. Judgments on compatibility of brands with different retail outlets could lead to spatial maps useful for making channel decisions.
- **Attitude scale construction**. MDS techniques can be used to develop the appropriate dimensionality and configuration of the attitude space.

Conducting multidimensional scaling

Figure 1 show the steps in MDS. The researcher must formulate the MDS problem carefully because a variety of data may be used as input into MDS. The researcher must also determine an appropriate form in which data should be obtained and select all MDS procedure for analyzing the data. An important aspect of the solution involves determining the number of dimensions for the spatial map. Also, the axes of the map should be labeled and the derived configuration interpreted. Finally, the researcher must assess the quality of the results obtained. We describe each these steps, beginning with problem formulation.

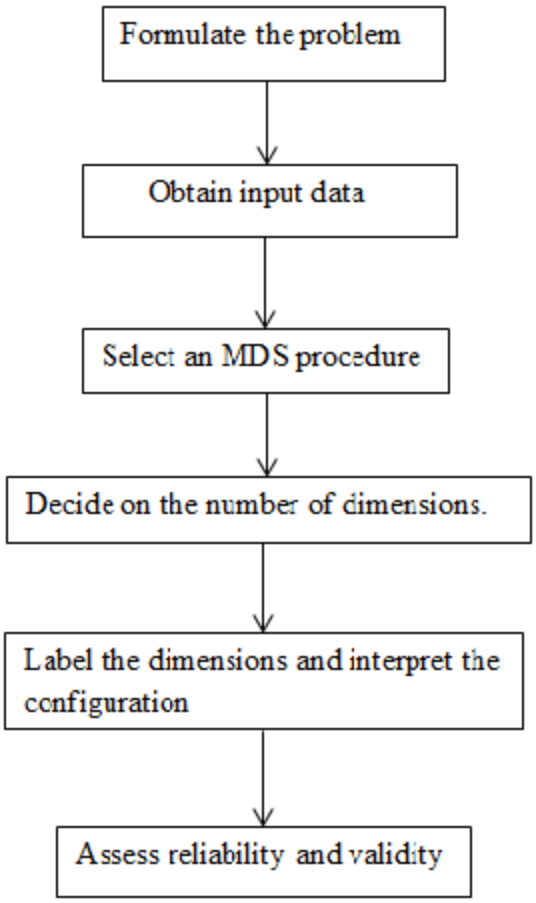

Figure 1 Conducting multi-dimensional Scaling

Formulate the problem

Formulating the problem requires that the researcher specify the purpose for which the MDS results would be used and select the brand or other stimuli to be include in analysis. The number of brand or stimuli selected and the specific brands included determine the nature of the resulting dimensions and configurations. At a minimum, eight brands or stimuli should be included so as to obtain a well-defined spatial map. Including more than 25 brands is likely to be cumbersome and may result in respondent fatigue.

The decision regardingwhich specific brands or stimuli to include should be made carefully. Suppose a researcher is interested in obtaining consumer perceptionsof automobiles. If luxuryautomobiles are not included in the stimuliset, this dimension may not emerge in the results. The choice of number and specificbrand and stimuli to be included should be based on the statement of marketing research problem, theory and the judgments of researcher.

Obtain input data

As shown Figure 2, input data obtained from the respondents may be related to perception or preferences. Perfection data, which may be direct or derives, is discussed first.

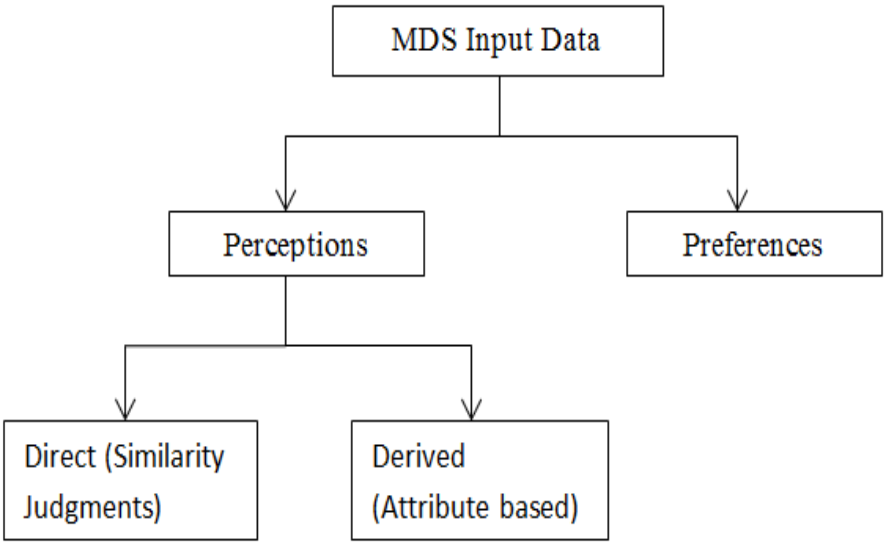

Figure 2 Input data for Multi-dimensional Scaling

Perception data: Direct Approaches.

In direct approaches to gathering perception data, the respondents are asked to judge how similar or dissimilar the various brands or stimuli are using their own criteria. Respondents are often required to rate all possible pair of brands or stimuli in terms of similarity on a Likert scale. These data are referred to as similarity judgments. For example, similarity judgment on all possible pairs of toothpaste brands may be obtained in the following manner.

Perception Data : Derived Approaches, Derived approaches to collect perception data are attribute-based approaches requiring the respondent to rate the brand or stimuli on the identified attributes using semantic differential or Likert scale example, the different brands of toothpastes may be rated on attributes such as these

Sometimes an ideal brand is also included in the stimulus set. The respondent askedto evaluate their hypothetical ideal brand on the same set of attribute. If attribute rating are obtained, a similarity measure (such as Euclidean distance) is derived force pair of brand.

Direct vs. Derived Approaches:

Direct approaches have advantages thus researcher does not have to identify a set of salient attributes. Respondent makes stimuli judgment using their own criteria, as they would under normal circumstances disadvantages is that the criteria are influenced by the brands and stimuli being evaluated. If the various brands of automobiles being evaluated are in the same price range, then price will not emerge not as an important factor. It may be difficult to determine before analyze and how the individual respondent judgment should be combined. Furthermost, it is difficult to label the dimension of the spatial map.

The advantage of the attribute-based approach is that it is easy to identify respondent with homogeneous perceptions. The respondent can be clusteredthe advantage of the dimension based on rating. It is also easier to label the dimension. A disadvantage is that

the researches identify all salient attributes, a different task. The spatial map obtained depends on the attributes identified.

Preference data: Preference data order the brand or stimuli in terms of respondent preference for some property. A common way in which such data are obtained is preference rating. Respondent are required to rank the brand from the most preferred to the least preferred. Alternatively, respondent may be required to make paired comparison and indicate which brand in a pair they prefer. Another method is to obtain preference rating for the various brands. Whenspatial maps are based on preference data, distance implies difference in preference. The configuration derived from preference data may differ greatly from that obtained from similarity data. Two brands may be perceived as different in similarity map yet similar in a preference map and vice versa. From example, Crest and Pepsodent may be perceived by a group of respondents as very different brands and thus appear far apart on a perception map. However these two brands may be about equally preferred and appear close together on a preference map.

Select an MDS Procedure

Selection of a specific MDS procedure depends upon whether perception or preference data are being scaled,or whether the analysis requires both kinds of data.The nature of the input data is also a determining factor.Nonmetric MDSprocedures assume that the input data are ordinal,but they result in the metric output.The distances in the resulting spatial map may be assumed to be interval scaled.These procedures find,in a given dimensionality, a spatial map whose rank orders of estimated distances brands and stimuli best preserve or reproduce the input rank orders. In contrast, Metric MDS methods assume that input data are metric.Because the output is also metric,a stronger relationship between the output and input data is maintained,and the metric (interval or ratio) qualities of the input data are preserved.The metric and non-metric methods produce similar results.

Another factor influencing the selection of a procedure is whether the MDS analysis will be conducted at the individual respondent level or at an aggregate level. In individual level analysis, the data is analyzed separately for each respondent, resulting in a spatial map for each respondent. Although individual level analysis is useful from a research perspective, it is not appealing from managerial standpoint. Marketing strategies are typically formulated at the segment or aggregate level, rather than at the individual level. If the aggregate-level analysis is conducted, some assumption must be made in aggregating individual data. Typically it is assumed that all respondents use the same dimensions to evaluate the brand or stimuli, but that different respondents weight these common dimensions differentially.

Label the Dimensions and Interpret the Configuration

Once a spatial map is developed, the dimensions must be labeled and the configuration interpreted. Labeling the dimensions requires subjective judgment on the part of the researcher. The following guidelines can assist in this task:

1. Even if direct similarity judgments are obtained, ratings of the brands or researcher supplied attributes may still be collected. The axes may then be labeled for the attributes with which they are most closely aligned.

2. After providing direct similarities or preference data, the respondents may be asked to indicate the criteria the used in making their evaluations.These criteria may then be subjectively related to the spatial map to label the dimensions.
3. If possible, the respondents can be shown their spatial maps and asked to label the dimensions by inspecting the configurations.
4. If objective characteristics of the brands are available (e.g., horsepower or miles per gallon for automobiles), these could be used as an aid in interpreting the subjective dimensions of spatial maps.

Assess Reliabilities and Validity

The input data, and consequently the MDS solutions, are invariably subject to sub random variability. Hence, it is necessary that some assessment be made of the relation and validity of MDS solutions. The following guidelines are suggested.

1. The index of fit, or *R* -square, should be examined. This is squared correlation index that indices the proportional of variance of the optimally scaled data that can be accounted for the MDS procedure. Thus, it indicates how well the MDS model fits the input data. Although higher values of *R*-square are desirable, values of 0.60 or better are considered acceptable.
2. Stress values are also indicative of the quality of MDS solutions. Whereas *R*- square is a measure of goodness of fit, stress measures badness of fit, or the proportion of variance of the optimally scaled data that is not accounted for the MDS model. Stress values vary with the type of MDS procedure and the data being analyzed. For Kruskal's stress formula 1, the recommendations for evaluating stress values are as follows.

Stress (%)	Goodness of fit
20	**poor**
10	**fair**
5	**good**
2.5	**excellent**
0	**perfect**

3. If an aggregate-level analysis has been done, the original data should be split into two or more parts. MDS analysis should be conducted separately on each part and the results compared.
4. Stimuli can be selectively from the input data and the solutions determined for the remaining stimuli.
5. A random error term could be added to the input data. The resulting data are subjected to MDS analysis and the solutions compared.
6. The input data could be collected at two different points in time and the test-retest reliability different.

ASSUMPTION AND LIMITATIONS OF MDS

It is worthwhile to point out some assumptions and limitations of MDS. It is assumed that the similarity of stimulus A to B is the same as the similarity of stimulus B to A there are

some instances where the assumption may be violated. For example, Mexico is perceived as more similar to United States than the United States is to Mexico. MDS assumes that the distance (similarity) between two stimuli is some function of their partial similarities on each of several perceptual dimensions. Not much research has been done to test this assumption. When a spatial map is obtained, it is assured that interpoint distances are ratio scaled and that the axes of the map are multidimensionally intervaled scaled. A limitation of MDS is that dimension interpretation relating physical changes in brands or stimuli to changes in the perceptual map is difficult at best.