THE USE OF MULTIDIMENSIONAL SCALING TYPE TECHNIQUES IN THE STRUCTURING OF THE ARCHITECTURAL PSYCHOLOGY OF PLACES

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Abstract

A short introduction to Multidimensional scaling techniques is given in the context of studies into the meaning of rooms. Three examples of applications are given; an analysis of perceived similarities of room names, which leads to conclusions about underlying components and the specificity of room meaning; judgements of the appropriateness of activities to rooms which are shown to have similar patterns of meaning; and a grid of furniture occurrences in rooms which yelded less clear patterns, but still the same structures could be discerned. The advantages for environmental psychology of such techniques are summarized.

Introduction

Previous work in the adjectival rating of places can be summarized as showing the prepotence of evaluative dimensions. However in most of these studies the criteria for evaluation are usually implied by the nature of the stimuli, and of the subjects, and this nature, as an important aspect of environmental meaning, requires further study. Wools & Canter (1970) discuss the way in which differences between groups produce changes in the salience of environmental aspect, by introducing the concept of appropriateness. What an adjectival evaluation may thus be doing is recording the appropriateness of a particular environmental "stimuli" to a series of unstated criteria that each individual has in the judging situation. These may depend on the nature of the judging task, the situation as a whole, on aspects of the individual (interest groups as well as personality), and possibly culture-wide differences. However the investigation of such criteria requires procedures approriate to the more complex structure of such environmental meaning.

Multivariate data analysis can be described as a process of collapsing certain aspects of collected data and representing the relationship between other aspects in a parsimonious fashion. A typical factor analysis of environmental rating data deals with

the three aspects of the data block (Subjects,Stimuli & Scales) by collapsing the first two , through calculation of correlation coefficients,and then seeking a best representation of the relationship between the rating scales,through metric variance-explaining techniques.

Multidimensional Scaling (M.D.S.) is a term which is now generally applied to multivariate methods that are not fixed to the metric and variance assumptions upon which regression and factor analysis are based.Non-metric M.D.S.procedures,first created by Roger Shepard in 1962,use only the ordinal(rank-order) information from a block of data and thereby enable a simpler representation of the meaning than classical techniques.The selected non-metric constraints give information for an optimal positioning of points representing the aspects of that data,such that the distances between the points in the representing configuration are best-fitted to the rank order of the input data.Interpretation of the distribution of the points,where the more similar points are nearer together,enables the generation of hypotheses about the meaning systems underlying the pattern of the data.

George Kelly's(1955) Personal Construct theory,though concentrating on interpersonal cognition examples,can be seen to give structural ideas of relevence to the cognition of places.The basic conception of each individual having a system of anticapatory constructs is articulated with various structures of the construct system.These are related to ideas of cognitive complexity (Bieri et al,1966).At the level of the individual construct,there are two structural concepts,focus and range of convenience,which describe the limitation of the constructs to particular areas of meaning where they are,respectively,most and adequately discerning.This can be seen to relate to the idea of the appropriateness of a particular place for a particular function;it is the further articulation of these concepts in the systems of meaning underlying the cognition of place that this paper will now unfold.

Perceived similarity of room names

An examination of the nature of an environmental judging situation would reveal the importance of differences in the type of place that is being judged as well as in the criteria,implicit or explicit on which the judgements are based.This first example describes work which tries to expose the basic structure behind types of places.

A group of students were instructed to write down all the names of interior places that they could recall.The most commonly elicited twenty of these names,were retained for a similarity judgement task,as being likely to be familiar to other respondents.

A group of ninety Scottish high school students made the judgements of similarity between the pairs of room names,on seven point scales.By a random balencing procedure,the 190 pairs were divided into three groups,enabling a subject's task to be reduced to about fifteen minutes.This data was then aggregated into a twenty element association matrix:the cells of the matrix were thus arithmetic means of about thirty judgements of similarity for the pairs of room names.

This matrix was then analyzed by Guttman-Lingoes'(1965) Smallest Space Analysis - 1 (SSA-1),which is a nonmetric MDS program. The process of analysis is represented in Figure 1.

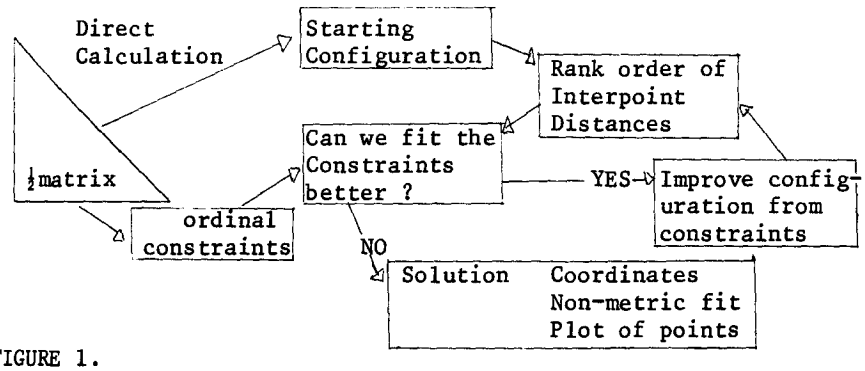


FIGURE 1.
Diagram of the workings of a nonmetric Multidimensional Scaling algorithm.

The important aspects of the procedure to note is that the algorithm works through a successive approximation or iteration to a best-fit of the ordinal constraints.However it has to work through a direct calculation from the figures themselves to produce a starting configuration.The workings of this procedure are essentially the same as other programs,such as MDSCAL and TORSCA,for non-metric MDS.

Figure 2 shows the plot from the analysis ,with the names of the rooms about which the judgements were made,typed on the plot. This is the plot from which we can develop hypotheses about the underlying differences among types of rooms,because the distances between the points have been forced into representing the information in the mean similarity judgement matrix.

As Euclidean distances between points are not altered by rotation of axes,the orientation of this plot is essentially arbitrary. However the orientation is selected so that the broadest (in a mathematical sense) way across the cloud of points is from left to right.

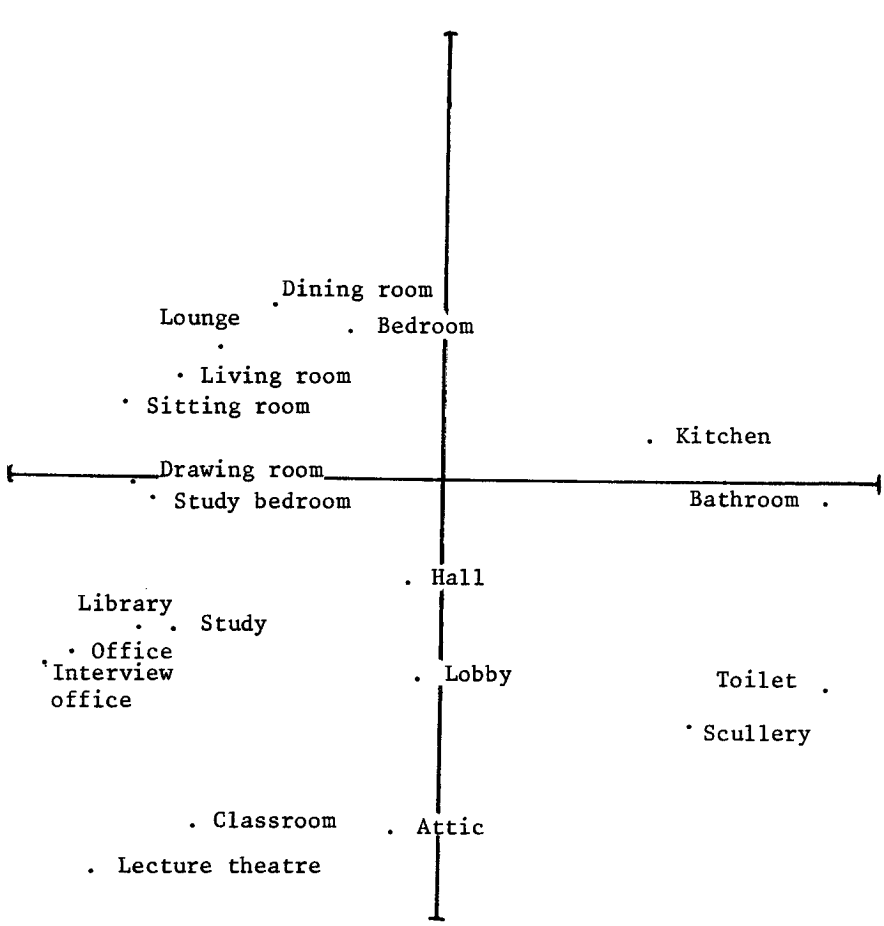


FIGURE 2.
SSA-1 Two-dimensional plot : School Students room similarity judgements . Non-metric fit (coefficient of alienation)= 0.203 .

We can see that the largest difference between rooms (as judged by our sample) is between Kitchen,Bathroom,Toilet and Scullery and most other rooms.We can interpret what might underly this axis in several ways:"wet",serviced,backstage rooms on the right are differentiated from "dry",less serviced,frontal regions.The first two concepts are related to architectural differences,and the third to the social situation(Goffman,1959).The up-down dimension can be seen to differentiate home-central rooms(at the top),from rooms less concerned with informal social life.This holds for both the right ,where toilet and scullery are less social than kitchen and bathroom ,and left,where lounge and bedroom are more social than classroom and office.

The non-metric fit or coefficient of alienation is quite high indicating that the two-dimensional solution does not represent all the rank-order information.In the three-dimensional solution where the fit is more acceptable,the extra dimension coveys the similarity between Bedroom,Study bedroom and attic.

Interpreting the axes is not the only way of finding meaning in the plot.The groupings of the points into small areas,can be seen as providing a clustering of sorts:the rooms with points in the same region are more similar to each other than they are to the points in the next region.However,application of hierarchical clustering analysis to the similarity judgements according to Miller's (1969) interpretation of Johnson's (1967) process, revealed that a clustering model does not adequately represent the data.

There is another aspect of a cloud of points that can be interpeted.This is the fact that some points are around the outside and that others are in the middle.In this case the room names with points around the outside seem to have more specific meaning than those in the centre.In other words,Hall,Lobby and Attic are less defined in their meaning whereas rooms like Bathroom and Office have more specific functions.

As a summary,we can think of a circular area of a certain critical size around each point : in this area the same sort of criteria for evaluation may exist.Also within this area we might hypothesize that similar functions would be fulfilled by the types of places there : in other words that similar activities will be associated with the type of places in that area.

Rooms and Activities

To follow up this latter line of thinking,another group of students were asked to rate thirty activities(that had been collected by a similar process as that used for the room names)on their appropriateness to six named room types.The raw rankings were aggregated to a mean matrix,a grid of thirty activities by six rooms.This was analyzed by a more advanced Multidimensional Scaling procedure,Guttman-Lingoes'(1970) SSAP-1(Smallest Space Analysis,partitioned matrix - 1).Figure three summarizes something of the process of this algorithm.

The main difference between this and the SSA-1 program is in the introduction of three sets of constraints to be seperately and jointly best-fitted.The solution of this program is a Joint Space,with points for both rows and columns:the interpoint distances which are shaped by the constraints are both those within the three sets and those between.

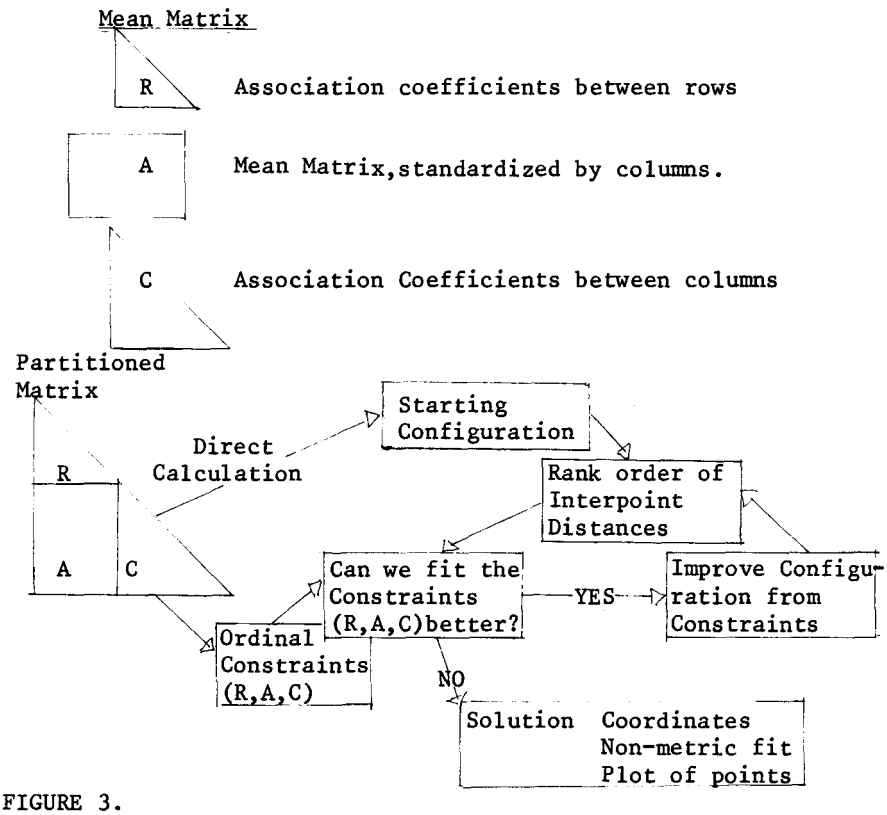
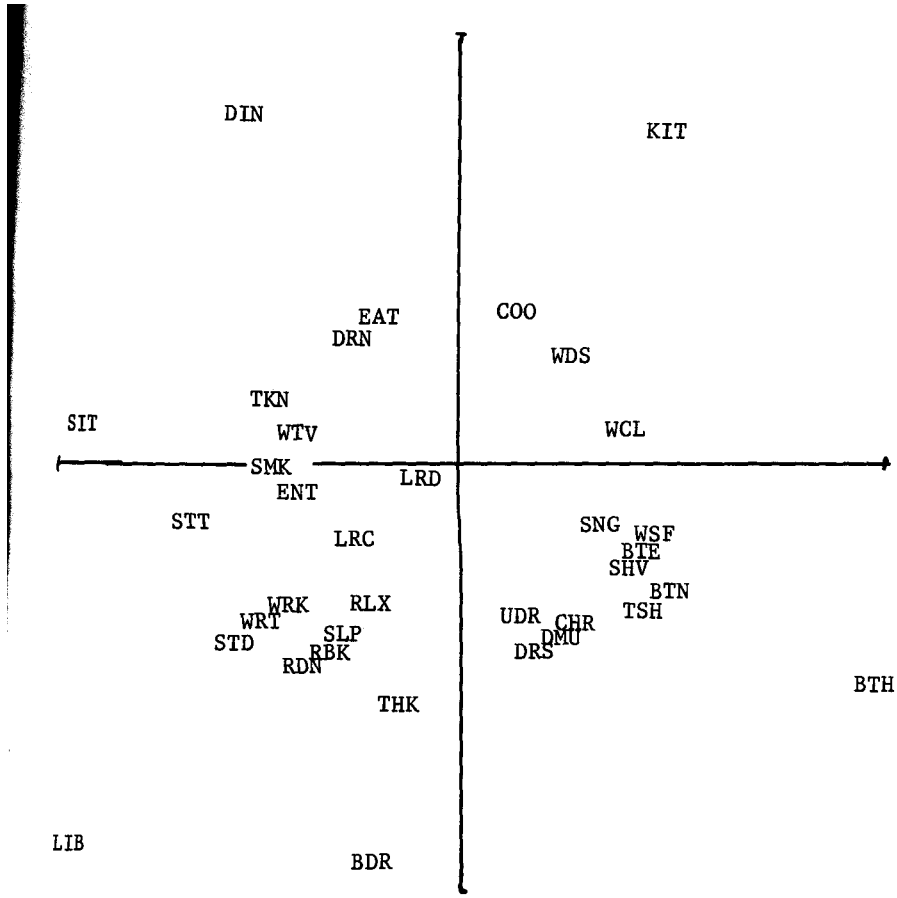


FIGURE 3.
Diagram of the working of the Guttman-Lingoes program SSAP-1.

Figure Four is a plot of the results of the analysis of the mean matrix.In this the points for room names are around the outside and the activity points are in a cloud in the middle.The points are represented by a three letter code,which is keyed at the bottom of the figure.

The Left-right axis is once again simply the "fattest" way through the cloud of points.Once again it differentiates wet rooms on the right and dry rooms on the left.Associated with this there is a spread of the activity points so that they are nearest to the room to which they were rated appropriate.The activities on the right tie in with the interpretation of the wet-dry axis as a backstage-frontal region one,as those on the right hand side seem to be uniformly grooming & cooking and others concerned with the more private preperation of face.



DIN Dining room	SIT Sitting room	LIB Library
KIT Kitchen	BTH Bathroom	BDR Bedroom
EAT Eating	DRN Drinking	TKN Talking
WTV Watching T.V.	SMK Smoking	ENT Entertaining
STT Sitting	WRK Working	LRC Listening to records
WRT Writing	STD Studying	RDN Reading
RBK Reading books	SLP Sleeping	RLX Relaxing
COO Cooking	WDS Washing dishes	LRD Listening to radio
WCL Washing clothes	SNG Singing	WSF Washing self
BTE Brushing teeth	SHV Shaving	BTN Bathing
TSH Taking a shower	CHR Combing hair	DMU Doing make-up
DRS Dressing	THK Thinking	UDR Undressing

FIGURE 4.
SSAP-1 two-dimensional plot :mean activity & room matrix.
Nonmetric fit (coefficient of alienation) = .187

The central activity points can be seen as unspecialized,as they must be equidistant from all the room points.More peripheral ones will correspondingly be more specific in thir meaning.This holds for room names as well.Library must be more specialized in its meaning,as it is further from the centre of the plot than the majority of the room points.Examination of the mean judgements reveals that Bedroom is the most general of rooms,with more activity types judged appropriate.Bedrooms were shown to have a wide range of appropriate activities for students,in some research reported in Sommer(1969).

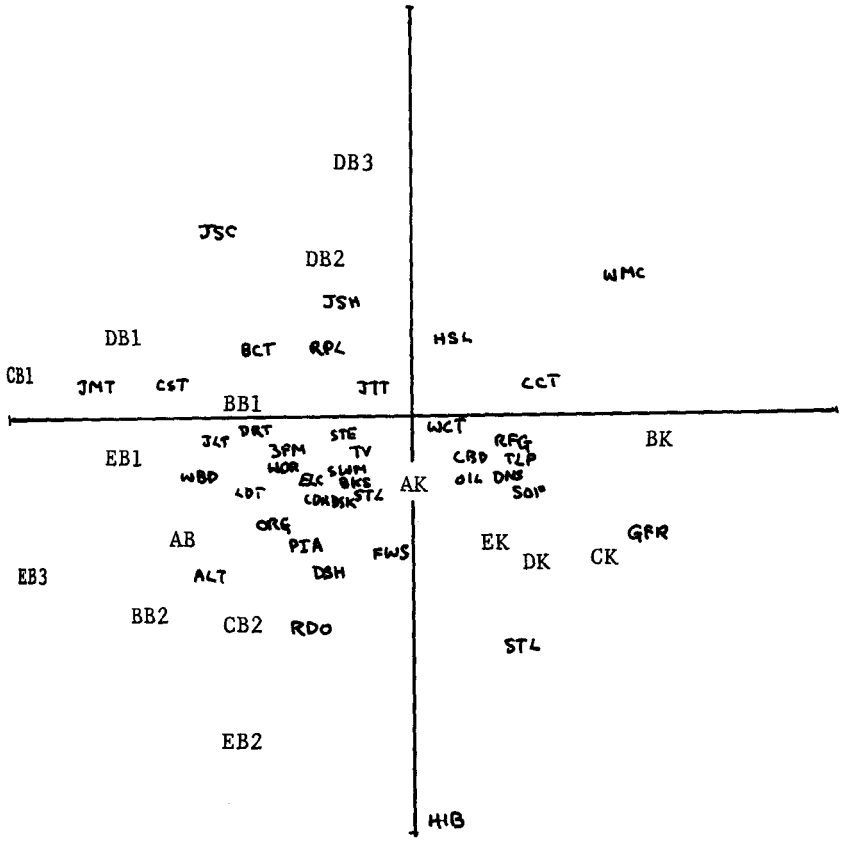
We can compare this plot with guttman's mathematical one of a radex.As we go around the outside of the cloud of activity points the kind of room to which the activities are appropriate change : and as one goes in and out from the centre the activities vary in specificity or inversly in complexity.(Guttman & Schlesinger,1967)

Rooms and Furniture

This last example uses data that needs a number of acknowledgements.Firstly to Professor Suzuki of Tokyo University,who collected it:then to David Canter who collected it from him,and gave it to Mr Lee at Strathclyde,who collated it and then gave it to me for analysis.As I suspect that all three of the above have more right to discuss the significance of the data,I will restrict myself to One paragraph of interpretation.

The Data matrix was the frequency of occurence of certain categories of furniture in Five types of houses.In fact the rows of the matrix were the eleven different rooms in the houses.The program SSAP-1 was used to produce the plot that is shown as Figure 5, with one difference;this was to use an association coeficient appropriate to frequency data.

Rather than a cloud of the same type as the activities,this plot shows the furniture points distributed ,as if dropped from a height with a higher density in the central region.This suggests that apart from the obvious difference between kitchen items on the right and bedroom items on the left,it is the centrality of each point that is significant.If a room point is near the centre it is likely to have a larger number and range of furniture in it and if a furniture point is nearer the centre it is likely to be in a larger number of different kinds of room.This,I believe is the basis on which this plot has been interpreted by the other authors.It relates to the variation in specificity that was discussed in the previous examples.



A = 1 dining/kitchen(AK) and 1 bedroom (AB)
B = 1 dining/kitchen (BK) and 2 bedrooms (BB1,BB2)
C = 1 kitchen (CK) and 2 bedrooms (CB1,CB2)
D = 1 dining/kitchen (DK) and 3 bedrooms (DB1,DB2,DB3)
E = 1 kitchen (CK) and 3 bedrooms (EB1,EB2,EB3)

JSC Japanese Sitting Cushion CDR Chest of drawers DSK Desk
HSL Hanging shelves JSH Japanese sitting chair BCT Baby cabinet
RPL Record Player JTT Japanese tea table CST Coat stand STE Stereo
JMT Japanese matress DRT Dressing table JLT Japanese low table
TV Television SWM Sewing machine BKS Bookcase STL Stool RDO Radio
ELC Electric fire LDT Low dining table WDR Wardrobe ORG Organ
3FM 3face mirror WBD Western Beds PIA Piano ALT Altar HIB Hibachi
DSH Display shelves STL Side table WCT Western Coffee table
CBD Cupboard OIL Oil stove RFG Refrigerator TLP Telephone
DNS Dining Suite SOF Sofa GFR Gas fire CCT China cabinet
WMC Washing Machine TRL Trolley

FIGURE 5. SSAP-1 two-dimensional plot : furniture occurence table
Nonmetric fit (coefficient of alienation) = .216

Conclusions

The desired effect of this report is to show how the use of Multidimensional scaling type techniques can be helpful in the development of concepts pertinent to environmental meaning.The range of appropriateness idea that has been in common between the three example studies has been directly apparent from the nature of the plots.

In the last two analyses,"grids" of data have been analyzed.If one makes an analogy between such environmental grids and classical repertory grids,one can converge on the Kelly concepts which were introduced early in this paper.The ideas of focus and range of application of constructs,appears very similar to the specificity concept that is so apparent in the examples.

The Multidimensional scaling procedures described,have advantages over traditional metric analysis in having wider applicability. As they do not rely on metric assumptions about data,they are appropriate to a wider range of data without any great alteration. This enables a relatively uniform approach to hypothesis-generation data-analysis to be maintained.

The value of such MDS techniques in Architectural Psychology is such that they are appropriate to the unstructured nature of a large number of areas within the field.However it should be stressed that their use requires a large amount of computer time, and that they are not a cure-all for all data analysis problems. However the advantage they have in giving a readily interpretable plot,that yields ideas of both the content and structure of meaning,should ensure that they will continue to be used more within this field.

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