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Multivariate  
statistical analysis  
in architectural design

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## MULTIVARIATE STATISTICAL ANALYSIS IN ARCHITECTURAL DESIGN

J.P. Maroy - J.P. Peneau\*

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### Abstract

Design methods are often presented as global answers to global problems of design. But they can only define and solve partial problems and, in fact, most of them appear to be classification issues. Multivariate Statistical Analysis is then an efficient and adequate tool to solve them. This paper describes applications of classification techniques to various specific design problems.

### Résumé

Les méthodes de conception sont souvent présentées comme des réponses générales à des problèmes généraux de conception. Cependant elles ne font que définir et résoudre des problèmes partiels. Et en fait ces problèmes se rattachent pour la plupart à des problèmes de classification. L'analyse des données est alors un outil efficace et bien adapté pour les résoudre. Ce papier décrit quelques applications de techniques de classification automatique à des problèmes de conception en Architecture.

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## INTRODUCTION

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The first aspect to be underlined is the importance of using various representations of the same data. The Analysis is used to give a synthetic (and therefore somehow inaccurate) view of the data. Each method brings to evidence a character of the data set and introduces a special bias. It is only by the association of different point of views that the synthetic idea can overcome a crude interpretation.

But then a new problem arises which is also important : how not to be overwhelmed by a set of interpretations larger than the original set of data which generated it ? We partially avoided this problem by using only one metric space.

The second aspect is the iterative use of the classification methods. Apart from the fact that the very status of the data used in architecture requires an iterative use it can lead to interesting problems of comparison of different analysis of slightly modified data sets and their use for time series analysis for example.

The second paper describes a real application of multivariate analysis as a community game where it is valuable as a communication media as well as an iterative analysis support. This last part is more devoted to architectural problems and mainly aims to overcome the differences of knowledge between the user of a building and the designer.

The following two papers were presented to the Design Activity Conference held in London (Aug. 1973). They show two aspects of the subject.



MULTIVARIATE STATISTICAL ANALYSIS IN ARCHITECTURAL DESIGN

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ABSTRACT

Design methods are often presented as global answers to global problems of design. However they can only define and solve partial problems of design, and in fact, most of them appear to be classification problems. Multivariate Statistical Analysis is then an efficient and adequate tool to solve them.

This paper describes applications of classification techniques to various specific design problems :

- a new presentation for the decomposition of the design problem,
- a study of qualities of activity bearing spaces for architectural programming and design,
- a new presentation of location-allocation and plan layout problems.

This use of Multivariate Analysis is quite new and interesting even for the statistician because it led us to tackle some special and characteristic problems such as the fact that the data we analyse is never fixed once for all. Since the design process simultaneously analyses and generates its own data, it allows it to vary in the very course of the process. Besides we never work on really large arrays so that it raises two more problems : how far is it legitimate to use statistical methods and how can we verify the results of the Analysis ?

The method is quite original for the Architect too. It offers him a creative utilisation of elsewhere analytic methods. This creativity proceeds from relying on the descriptive character of Multivariate Analysis and by offering graphic visualisations, easy to manipulate, of the structures of the data the designer handles.

The unifying prospect that derives from the application of a single methodology to different steps of the design process is quite interesting, mainly for pedagogical reasons. But the questions that may arise from the use of any analytical technique remain: do not they tend to duplicate existing models and to conceal ideologies ?

INTRODUCTION

The use of statistical methods as aids in Architectural Design may be startling at first sight. The data the Architect works with is known as being important and difficult to grasp as a whole but it is not large enough to justify a statistical treatment nor its form particularly suited to it. However multivariate analysis can be used in Architectural Design to give synthetic representations of the structure of the design problem.

The idea we rely upon in this study is that an Architectural Design problem can be formalized, at least partly, by a set of items related together by various kinds of relationship. The resolution can then be identified as a decomposition into independent sub-systems. Ch. Alexander [1] proposed a design-oriented formalisation. We will show that other approaches can also be formalized with the same model.

Those different approaches will be distinct in the definition of the design items and their relations. This will have in common the statistical model employed, the search of a structure representing correctly the problem and modifications of this structure as part of the design process.

Then the design process itself can be seen not as an optimisation problem but as a representation problem and the transformations of various representations from the programmatic analysis and the design brief to the completed building.

Instead of relying on the mathematical foundation of multivariate analysis we prefer to insist upon some may be very simple aspects of representation problems which we think important for the use of those methods, mainly to give an intuitive feeling of the meaning of the results.

Statistical Methods

Multivariate Analysis Methods themselves can be classified (as long as they are classification methods) in various ways. They can be global (factor analysis) or local (clustering). They can be aggregative or work by decomposition. They differ by the algorithms implemented [6], by the similarity measures they use (Hall [9], Lerman [11]), by the representations of the structures of the data they offer. This last distinction is quite important for the practitioner because he will work on those representations.

This representation problem is fundamental because it is related to the structure the method is able to find. If we find a distribution of data as in fig. 1 we know we have a linear distribution and that, apart from slight "experimental" errors, those points should lie on the line drawn through the cluster of points. Such fitting can be made on other simple analytical functions. Multivariate Analysis looks also for simple clusters as those of fig. 2.

The aim is here more general and multivariate analysis can be considered as aiming to a simplification of data into a few distinct classes.

The Data

The data processed by Multivariate Analysis has to be a two-dimensional array. Usually a line of this array represents the measures of an item in respect to various characters. We will not enter here the very important question of the nature of the quantities here observed: numerical, ordinal and so on...

In Architectural Design we will mainly work on qualitative or subjective data that can always be coded in 0-1 or on a simple scale of 0 to 9 for example. Anyway the data we will work with is not precise enough to justify absolutely a numerical code.

For now on the Clustering techniques will work on the objects or items represented by their description or coding. It is only when the architect will work on the results of the classification process that semantics and exogenous knowledge on the data will be re-introduced.

Distances and Similarities

How can we define the clusters we are looking for? On figure 2, we can assume that two points belong to the same cluster if they are close enough. At least two points in a cluster are closer to each other than are two points belonging to other clusters. If two points are in the same cluster we see that they have approximately the same values of variable 1 and of variable 2. Since we know a point only by its two coordinates we say that two points belonging to the same cluster are more alike than two points of distinct clusters by examining their coordinates.

Then we will define an index on the coordinates of the two points, that will represent their similarity.

Consider three points A, B and C in Euclidian space (fig 3) we can measure their distance with the Euclidian distance (fig 4). But if we consider Manhattan distance then the distances between them are given by the array of figure 5. We can construct A', B', C' in an Euclidian space which display the same distances. They are different from A, B and C.

This example shows two things. First, that the choice of a distance between items is important. Then, that given a distance, we can look for points distributed in Euclidian space, that have same inter-points distances. This last property will be used by Factor Analysis.

Now we would like to introduce a particular metric the khi-2 metric.

Suppose for example that we study three towns i, j and k and that we compare their population, their surface, the degree of air pollution and so on. The data can be stored in an array and the measures plotted on parallel scales (fig 6).

When comparing the profiles we can say that i is always over j. If the scales allow us to say that higher values on the scales are better values, then we can say that i is better than j. And we cannot say much of i and k.

But despite the fact that k is over j, we can say that they are quite alike. They have the same profile. If we think that it is an important property we want to have an index that says that k and j are close and k and i far apart.

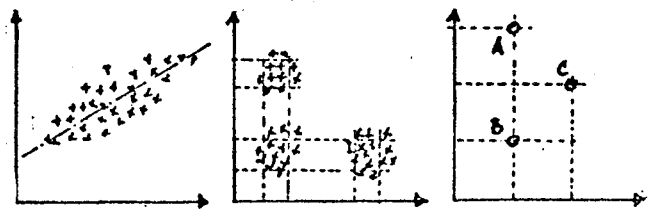


FIG 1 LINEAR FITTING  
FIG 2 CLUSTERS  
FIG 3 THREE POINTS IN EUCLIDIAN SPACE

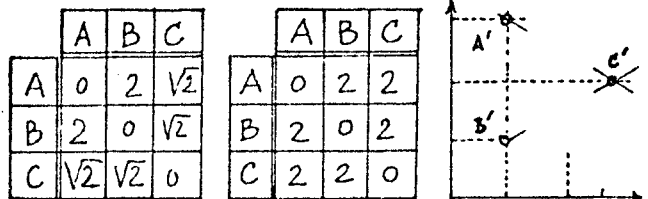


FIG 4 EUCLIDIAN DISTANCE BETWEEN A, B, C  
FIG 5 MANHATTAN DISTANCE BETWEEN A, B, C AND CONSTRUCTION OF A', B', C'

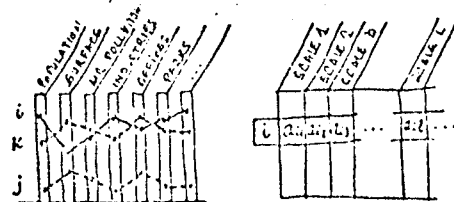


FIG 6. PROFILES OF MEASURES FOR TWO TOWNS. EACH TOWN IS REPRESENTED BY A SERIES OF NUMBERS



It is in fact an important property mainly if the measures are taken on very different scales. The khi-2 metric displays that property and can be expressed by

$$d^2(i,j) = \sum_{t=1}^N \frac{1}{\nu_t} \left( \frac{a_{it}}{\nu_i} - \frac{a_{jt}}{\nu_j} \right)^2$$

where  $\nu_i$  and  $\nu_j$  are the sums of elements of lines  $i$  and  $j$  and  $\nu_t$  the sum of elements of column  $t$ . The sum is then made on all columns.

Though if it is a good distance to use with frequencies or 0-1 data it should not be considered as a general distance. With numerical data we should be more careful, although by its averaging properties it also usually gives good results. While we still bear in mind the example of figure 7 we should notice that if we permute the order of the scales, the comparison between profiles can be easier. We will discuss this point further, in what we call "ordered arrays". And also, that the scales can be bent and arranged in such a way that the comparison of profiles can be changed into comparison of points, which can be carried out manually [14].

Finally, we can remark that the choice of the index is very important. It has to be defined so that the similarity between two items should be as close as it is possible from the real (or intuitive) knowledge we have of the similarity of the two objects represented by those items.

Then what is the use of retrieving a similarity we intuitively know? We can explain it by referring to Pattern Recognition which is a close problem [4]. When you have devised a program that recognises printed characters you expect it to recognise also slightly crooked designs of the same character. The problem is to know when this property of generalisation is no longer a quality but becomes an error of recognition.

Here we will find trivial relations any designer would be ashamed to mention. But we must consider them as fixed points that make us sure that we are right on those points at least. Then, we may accept other less trivial groupings as possible, or at least worth studying, clusters.

#### Clustering Algorithms

It is out of the scope of this paper to give a complete view of all clustering algorithms. The reader will find in [2] a complete survey published for the architects. The reader should also consult [7] which describes a type of algorithms we will not discuss here but that give a good intuitive idea of how clustering algorithms work.

We will mainly recall some properties of hierarchical clustering which has been described very well in Sokal [17] and presented, for designers, but without applications, by P. Tabor [18].

We will just insist on two points: it is a local method and it is strongly related to the hierarchical representation it gives of the structure of the data.

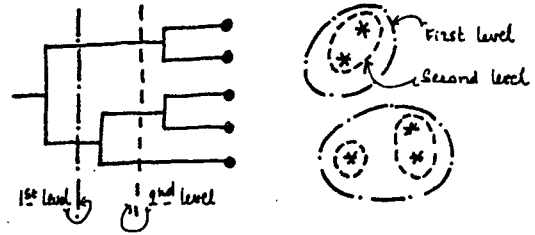


FIG.7. A TREE REPRESENTATION OF PROXIMITIES AND CORRESPONDING SET REPRESENTATION

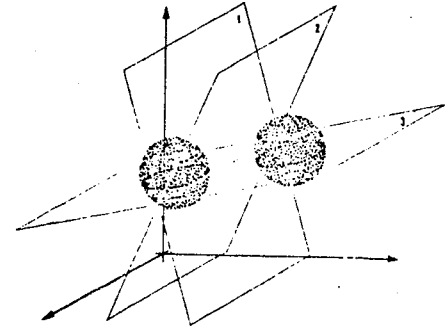


FIG.8. PROJECTION OF A 3-DIMENSIONAL SPACE ONTO A 2-DIMENSIONAL SPACE.

Local, means that the clusters are grown locally around each point without whole effects like in factor analysis.

The representation is quite straightforward. It is a tree, usually binary, which describes proximities between subsets of the data. Depending on the height of the cut through the tree we obtain partitions of different fineness (fig.7).

We can just recall that if two items are very much alike they will be very close and will then be aggregated at the beginning in the tree. So that when we cut the tree at a certain level, the subtrees or subsets we form are composed of items that are more alike than items belonging to different subsets.

The process is in a sense continuous: we choose the number of clusters we think significant from the study of the levels in the tree and from the semantics of the data.

#### Factor Analysis

Factor analysis is a global method of describing data. Various intuitive presentations of it can be given. The simplest is to say that we are looking for  $M$  points in an Euclidian plan such that distances between them are as close as possible to a matrix of distances given by a specified metric. This argument has been given earlier. It doesn't really cover Factor Analysis but all the techniques of mapping. Factor Analysis can be better expressed by a mechanistic presentation that is closer to the calculations actually performed.

An item can be seen as a point in a n-dimensional space. Then we look for the better subspace to project the set of points onto. This subspace must have its origine at the center of gravity of the points and its directions will be the successive axis of inertia of all the points. For example, if n-space has three dimensions as in fig 8b, of the three plans 1, 2 or 3, the best one is number 3. The calculation is then the search of the axis of inertia of the set of points.

But there is an important loss of informations. Two points can be close in projection without being close in space. So interpretation should be careful. This is why we use hierarchical clustering to cluster items and then we draw the boundaries of the clusters on the plan of the factor analysis.

Furthermore, if we use the khi-2 distance we can project characters and items on the same plan and the property that relative position of characters and items are significant. But its interpretation can be tricky [13].

Ordered Arrays

The data array can be re-ordered so as to show relations between clusters of items and clusters of characters. This ordering is quite easy to obtain from the hierarchical clustering scheme.

Suppose we are working on 0-1 data and that lines and columns of the data array are ordered by the result of the hierarchical clustering program. Then if a cluster of lines is related with a cluster of columns, the rectangle at the intersection of the lines and the columns of the two clusters will be filled mainly with ones and the other rectangles mainly empty.

Figure 9 shows how the clustering program is working and how the data array can be re-organized.

It is important to note that in this case there is no loss of information, but if the data doesn't show well separated clusters the array is not very clear. But at least it shows that the data is not well classified. Then the ordered array can be used to verify hypothesis drawn from the other two representations.

A last remark should be made on the fact that this ordering can be made on rectangular arrays and not only on square and symmetrical arrays [16].

Applications to design

The three applications to design we present here, besides their practical interest, are important for teaching because they show that three distinct design problems can be presented in a unique framework.

C. Alexander's first design methodology

It is too well known a method to be introduced here. We shall only mention that the items are design requirements. As characters we take the same requirements. And relations will give the 0 and 1 of the matrix. Now if we make clusters on that data we will find in the same clusters, requirements related together.

Running our program on the data of Community and Privacy [5] we found the same decomposition. We obtained the tree in one operation instead of two. And the ordered array (fig 10) allows us to analyse links between clusters. Overlapping points will be affected to both clusters.

Layout

The same model can be used. Items are rooms (or activities). Characters are the same rooms. The relationship between rooms gives the data array.

Then if we cluster the lines (or columns since the array is symmetrical) we will find in the same cluster rooms strongly related. Strongly means a strong relationship (high value) or all related together.

Furthermore, Factor Analysis gives the position in the plan of points such that their distances are as close as possible to the definition given here.

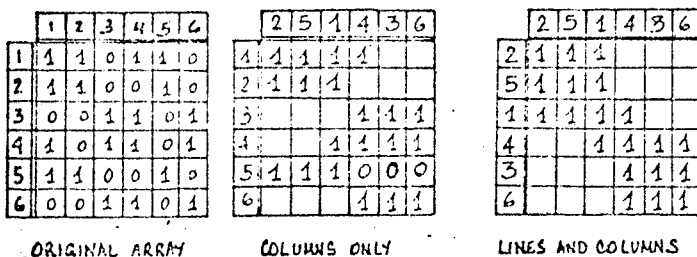


FIG 9 - REORDERING LINES AND COLUMNS OF AN ARRAY. THIS OPERATION CAN ALSO BE DONE ON A RECTANGULAR ARRAY.

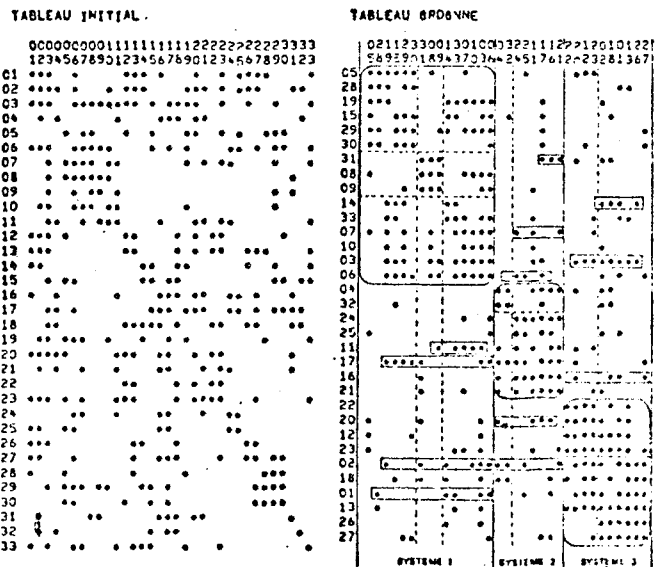


FIG 10. DATA ARRAY AND RE-ORDERED ARRAY ON THE DATA OF 'COMMUNITY AND PRIVACY'



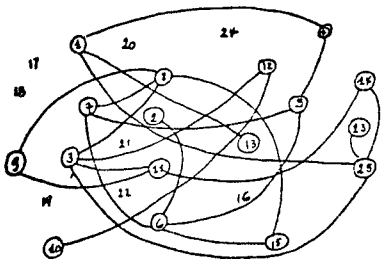


FIG. 11 a. THE ORIGINAL DATA: RELATIONS BETWEEN ROOMS IN A PLANT

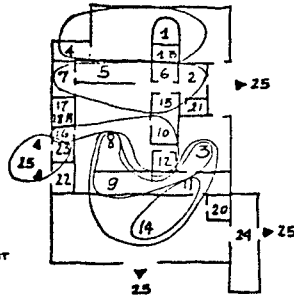


FIG. 11 b. THE PLAN GIVEN INDEPENDENTLY BY THE ARCHITECT WAS MADE ON THE SAME DATA

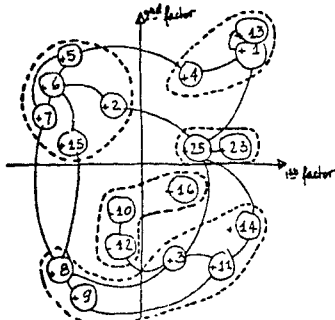


FIG. 11 c. FACTOR ANALYSIS. THE BOUNDARIES WERE DRAWN AFTER HIERARCHICAL CLUSTERING. LINES BETWEEN POINTS ARE THE SAME THAN IN FIG. 11 a. IT SHOWS SIMPLIFICATION OF THE DATA

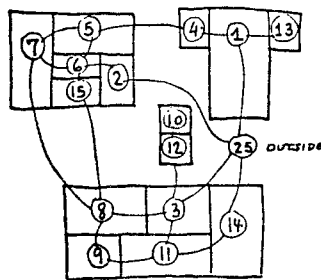


FIG. 11 d. SCHEMATIC LAYOUT GIVEN BY THE DUAL GRAPH FROM THE RELATION GRAPH

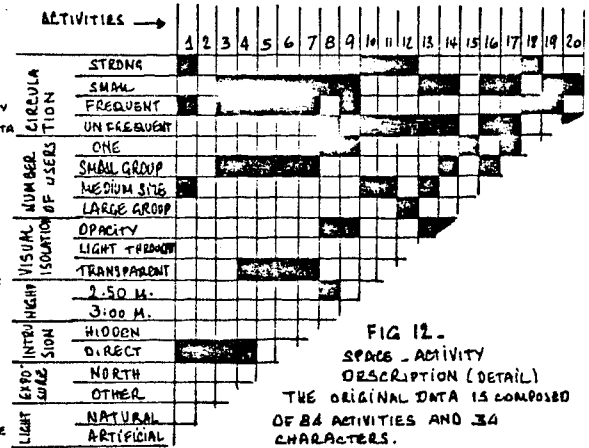


FIG. 12. SPACE - ACTIVITY DESCRIPTION (DETAIL). THE ORIGINAL DATA IS COMPOSED OF 20 ACTIVITIES AND 34 CHARACTERS.

Fig. 11 shows how these representations can be used to derive a plan. But we think we should stress here an important point. Relations given in the data array are studied by comparing one activity to another. If they are compared within an existing building their context will change. If the building does not exist, the context is unknown. Then the analysis is certainly wrong. But by a second analysis of the clusters we can build step after step the future context of the activities. Multivariate Analysis should be used as an iterative tool to include context in programmatic analysis.

### Programmatic Space Analysis

The two previous problems are really crude problems. The last one already shows that design can be seen as a multistage process that transforms one representation into another. It will be still more obvious here.

Plan layout assumes that we are working on some items very similar to rooms. But on many buildings the problem is so ill-defined that the definition of rooms is in itself a problem. Anyway it does not seem accurate to see a building as a collection of rooms. Things are not so simple.

In a few buildings the only concept we can rely upon is that of activity. It is not well defined but it is intuitively used by architects and begins to be studied by psychologists [15]. In another paper we discuss its use and describe a project for a social meeting place for a working class neighborhood [14]. In that study we found the concept of activity and the method of analysis a great help to exchange information between users, administrations and architects.

We first devised a list of activities as complete as possible and a list of characters that could describe the spaces into which the activities could fit (fig 12). Then the program gives us two hierarchical clusterings, one on the activities, the other on the characters, the Factor Analysis (fig 14) and the ordered array (fig 13).

When two activities are in the same cluster it means that they require similar space properties to shelter them. The clustering of two space characteristics means that they should belong to spaces sheltering the same sort of activities.

Then the two sets of clusters can be compared. The classification shows that only eight general properties allow to define the various spaces in the building. And for a given group of activities the ordered array shows that one or two sets of properties define the qualities of the spaces.

Factor Analysis can be used to analyse the different classes of the initial array: are two or three classes of temperature meaningful for this building? If we find two of the temperature characters in the same cluster, then we can say they are not really meaningful for this building.

Iterative use is also very important. Clusters of activities are sometimes unexpected. So we analyse the context introduced by the clustering and repeat the process as many times as necessary to find clusters satisfying both for detail and for the whole image. All along the process it allows us to explicit the means and ends of the design problems.





## GAMING WITH FACTOR ANALYSIS :

The User used ?

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### ABSTRACT

Before reaching the phase of conception of a building one must be fully aware of the nature of the different activities that should or may take place in it, successively or simultaneously. In order to study the conditions of flexibility, multifunctionality or banalisation of the different space units, we can order those "activity bearing spaces" according to suitably chosen descriptors. The methods of Multivariate Analysis are used here, mainly Hierarchical Analysis with Factor Analysis of Correspondances.

But that process remains abstract and technocratic unless the future users of the constructed building are somehow associated with its study. The method called here "Jeu factoriel des Correspondances" aims at the association of the people concerned in the future building to the definition of its program. The level of abstraction of that phase of the design process makes this association still more difficult than when it deals directly with spatial configurations as it more often does.

We will describe in this paper the study of a Community Center with the inhabitants of a low cost housing scheme in France. We will also try to answer these questions: -What problems arise from the use of this method? - Why is it interesting, and how far? - Can we straightway associate to the process, inhabitants that belong to the working-class? How far may the organizers influence the answers and impose their own conceptions? - What scientific conditions are required for the use of such methods that would limit to some extent any manipulation of the user?

## INTRODUCTION

Various works in the field of programming, space or architectural analysis refer to the idea of duality between activity and space - whether by correlating a system of activities with a spatial structure or more usually a system of functional needs with a spatial organization; such methods relating to a more or less ostensible "functionalism" lay hidden within the designer's production.

The question is whether the foundations of this correlation between activity and space are still valid with automatic data processing and, generally speaking, with a more systematic approach.

From a strictly point of view, neither the notion of activity nor that of space have a well-based status. To compare them is to refer to a theory of space use which does not exist yet. Such theory is likely to replace the notion of activity, considered in the abstract as an atom of behaviour, the concept of practice, in particular the social practice of space which expresses the sociological and psychological variables resulting from social relations. But we are obliged to note that, for the time being, the theoretical basis is weak. Thus, by lack of the tools enabling to meet reality significantly, we have to try to explain systematically such phenomena as space occupation, appropriation and use. The basis of the approach are still empirical, as most of the data come from conventional operations methods; it is only by practice that the procedure set out cross-checks the theoretical problem, namely the differential use of space by social agents.

The experiment described and the method used are indeed intended to state and then to try to minimize the problem of social distance which most generally occurs between the designer and the future user of the object planned. This distance results from the distortion between his class "habitus" projected by the designer, therefore between the ways of space use of this own class, and those sometimes very different of the user of the designed building.

From a practical point of view, we mean that such current or future uses can be well described in terms of space and activities. We make the restrictive assumption of a correlation between the

distribution of spatial units and so-called homogeneous elementary activities according to the intervening parties. In this regard, we shall consider the operations enabling to go from one set to another and make up homogeneous classes within each set.

Considering the set of activities as the initial set, the implementation likely to correlate activities with the elements of the set of spaces may be :

- "bijective" - in the case of a term-to-term correlation between spaces and activities.
- "subjective" - if several activities are taking place within the same space.
- almost never injective, since such alternative would correspond to spaces where there is no activity.

This sequence of operations does not express all the modes of correspondence. For there are diffuse activities which may take place within several spaces. The rules of implementation are no more relevant since the same element of the initial set would correspond to two (or more) elements of the final set.

The circumstances just set out mean for the designer specialization, polyvalence (simultaneous and successive) and "banalization", of spaces. It is specially for the definition of a spatial polyvalence that such a procedure is intended. The method used consists in specifying the activities likely to take place within a projected building, in choosing descriptors related to the space where such activities take place. At least in defining through an automatic classification program using the factor analysis of correspondences, the classes of activities with similar or closely related spatial characteristics.

The approach would be strictly technocratic if it were carried out only within the limited area of the programmers and designers of a future building was destined. This was very obvious in particular for the definition of activities as well as for the procedure of characterization of spaces. In the first place, cooperation bears on the joint implementation of a list activities. In the second place, it leads to a procedure of programming game called "the factorial game of correspondences". After a brief survey of both phases, we shall deal with the improvement they really bring to the mutual communication between architects and users. More generally speaking, we shall consider the scope of such an approach. Does it lead to a real democratization of decision-making ? Does it correspond to a mere manipulation of the users ? Does it bring more strictness in the programming work ? What are the scientific conditions likely to improve it basically ?

Answers to this series of questions may be already made in some respects.

#### Compiling a list of activities

The attempts to use the method of programming already described were made for the definition of a socio-cultural equipment for a neighbourhood.

The inhabitants of a district, especially those of a cheap dwelling group "Habitations Bon Marché" ("HRM") built in 1926, had been claiming unsuccessfully for the building of a social center. Thanks to cooperation with a working group from the "Unité Pédagogique d'Architecture", it was possible to organize the demand.

First of all, a phase of joint discussion and thought enabled architects and the inhabitants of this district to deal with the definition of the activities which were to take place within the planned facility. To simplify, the question was : "What do they want to do in the center ?"

Such an approach already raises numerous problems relating to the general notion of district facilities as well as to the way in which the inhabitants express their needs. Apart from rather diffuse and complex roles of control and recuperation, socio-cultural equipments play also an objective role of compensation and substitute for the inadequacy of housing, specially obvious here. Rather than from a more or less idealized need for culture or community life, the demands of the inhabitants originated indeed from tiny and comfortless dwellings which prevented them from any relations beyond the family cell.

This being clearly stated, we must consider the meaning of the question relating to the activities wished for the socio-cultural center. For want of an analysis of the ideology underlying this type of approach, we can rapidly note that the user is to answer the question in two main ways :

- the first way will consist in formulating again the stereotypes of activities which everybody bears in mind : to organize meetings, to do odd jobs, to play ping-pong etc... These activities are corresponding to those almost automatically associated with district facilities of the same kind.

- the second way depends on the more or less felt aspirations of a person or a group. Very often, they refer to "diagrams", or valorization or promotion expressing in a wish for oneself or one's children to do activities such as : ballet, music, learning languages and so on...

In both cases, it is clear that the aspirations of such or such individual only become meaningful through the knowledge of social determinisms underlying his behaviour and organizing his aspirations. The examined person usually does not know these determinisms. But the latter must be perfectly well known by the "game animators".

This requirement was not strictly fulfilled when the above experiments were carried out. The attendance of architects and architectural students more or less aware of the problems raised and wishing to solve them, has brought a third element in the compilation of a list of activities. Their opinions were rather typical of the traditional opinion of architects. They consisted in offering activities deemed "original" to the inhabitants of the district. Thus, activities such as the Brittany wrestling, the creation of a television studio in the district and flora art have come to finish off

the list, which finally bears 84 activities, in agreement with those concerned.

It is interesting to note that the matter of other possible activities which are not yet on the list or which may replace those falling into disuse does not seem to have concerned the participators. On the other hand, the need to find solutions of polyvalence, owing to the proposed limited area was kept in everybody's mind. Which enabled to go on with the next phase of characterization of the spaces where such activities take place.

#### The descriptors and their correlation

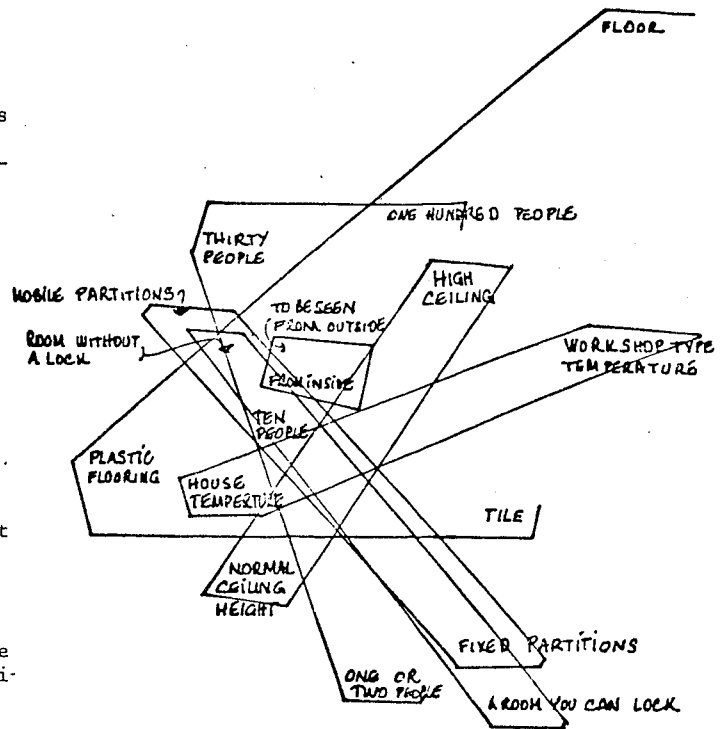
We have described in another paper [9], the procedure of automatic processing which enables to make up classes of activities corresponding to spaces with similar or closely related characteristics. We shall deal here with the difficulties we met with when specifying the characteristics of space or descriptors relating to it. We must immediately indicate that such characteristics do not refer to activities but to spaces where activities take place.

The characteristics may refer to notions relating to the activity in progress but, in any case, these notions must be expressed in terms of spatial requirements. Dimensions, layout, materials and temperatures and so on are the reference fields of such characterizations.

The main problem was to specify categories understandable by persons who knew nothing about the building field, its terminology and relevant notions. A simplified list of characteristics has been compiled from the too technical ones.

It was then possible in a first phase to set the discussions about spatial descriptions at a sufficient level. The starting-point of the play is a preliminary automatic processing representing classes of characteristics and classes of activities on a plan. Data enabling to make such an analysis have been determined a priori.

We shall use the plan given by factor analysis as a game board by suppressing one of the sets, namely the set of activities and keeping only the positions of the points which correspond to the characteristics within the subspace of representation. These characteristics initially make up subcategories which refer to a type of question and modes of answering it. Thus, as regards the ground, depending on the nature of the activity which is to take place on it, either flooring or a plastic coating or tiling will be chosen. These three possible choices determine three different descriptors in the data processing. However, they form a scale relating to the notion of height. This scale may be indicated on the representation plan with a continuous strip, which will be all the more long as the notion has a separative power in the organization of the whole set of activities. (The figure shows an example of a plan bearing such scales).



AN EXAMPLE OF THE GAMING BOARD SHOWING THE SCALES

From this plan, the play will consist in specifying for each activity the characteristics of a space which make possible a satisfactory development of the activity.

In order to materialize the activity in question for which we try to specify spatial characteristics, we use laminated plates with a graphic symbol representing the activity. (In another version of the play, the plates are used by players as a medium for the selection of activities).

The plate is handed round, its graphic is deciphered; and, indeed, its being physical holds our attention to the matter.

The characterization is made scale after scale. The choosing of one characteristic instead of another, the wavering between two characteristics are also materialized after group discussions, by placing a pawn on the scale. (The operation consists in positioning as many pawns as scales). Then the position of the centre of gravity of the located pawns is considered (through a very simple handling, which is usually appreciated by players). This builds a "trace" of points on which may be specified classes of equivalence representing activities with closely related characterizations.

#### Scope and Significance of the game

Merely in view of the operation of a collective programming tool as well as in the broader context of procedures of association, animation or participation, we are led by experience to make a lot of comments.

Although both aspects are closely linked, we shall deal successively with its technical interest in the context of architectural programming and its social scope in relation to the architect's practice in general.

The technical interest is obvious in many regards : we shall bear in mind in particular : the implementation of a minimal program and the check of an elementary level in the acceptability of the arrangements proposal to users. Such feasibility is limited by the descriptors used, which are not technical enough (It is clear that it would be impossible to perform this checking if the future users did not understand the nature of the information communicated).

Still at the same level, comparisons of the answers made a priori by technicians and uninitiated persons, resulting from a discussion with the future users carried out through a comparison of the results from manual and automatic processings. Such comparison is made thanks to a method of superposed analysis, used to test the stability of the "trace", the data once modified. It consists in superposing the results from manual and automatic processing and in locating the trajectory of the points representing activities from a data set to another. Differences are shown immediately, which can be analysed. It is useful, in order to check the terms of the comparison, to note down the answers for each category of characteristics in the course of the play. Thus, from these data, it is very easy to locate and interpret the modified characterizations.

Apart from the technical interest of both aspects, we can likewise observe induced effects as regards the compilation of the list of descriptors. Trying to compile a list of spatial descriptors which can be understood by anybody does not mean at all that descriptors are simplified. The technical aspect cross-checks the relevant problem of communications. It is indeed possible to go beyond a level of verbal formulations and define physical media which represent the descriptors. Some samples photographs and sorts of models may be used, and judging by our former trials, they will enable to understand perfectly notions deemed a priori to be a matter for professional or initiated people.

Such refining of the list of descriptors is also interesting as regards the transfer of data and information from other fields of study to architectural programming and design.

It is still difficult to use data specially related to space use and given by human sciences ; and the development of methods setting the problem in a practical way through space descriptions would be likely to promote our knowledge in the field.

Very often, the data or the results of the data processed by the psychologists or the sociologists are used directly by the architect who is sometimes led by his own objectives to remodel or misinterpret them ; in the worst case, he does not know what they really mean and misuses them.

Whatever it may be and for want of precise investigation of the matter, the modes of this transfer

will gradually become clear through the procedure of description already set out.

As regards the technical aspects, we shall deal at last with the extension of the proposed method.

First of all, it is a matter of suppressing the whole automatic processing. The preliminary game procedure will then take place in two phases, which consist in locating on the plan, first the descriptors, then the activities.

It came out from former trials that it was very difficult to achieve the first phase.

It is also possible to use the play as a tool of comparison between the various answers from various groups or persons. In such a case, a good knowledge of the psychological and sociological variables of the groups or persons participating in the game is necessary.

In this last part of our paper, we shall deal with matters relating to the social scope of the game and its implementing conditions.

One of the first ambiguities we observe as regards the word "game" is due to the fact that the notion of game is usually attached to a "gratuitous physical or mental activity which is only intended to please those dedicating to it". Such games and those organizing them are obviously serious. Some people, in order to distinguish their games from others call them "serious games".

Does the use of a game in order to speak about an object mean that this object is not interesting enough in itself or that the persons to whom it is destined are not able to speak about it directly ?

There is a range of answers to such question. They should be stated precisely not only in reference to the various types of procedures involved but to local implementing conditions. In one case, it will be mainly a matter of making a teaching less tedious. In another it will be obviously a mere handling aimed at pretending that some irresolute people are able to make decisions. We must also bear in mind the distinction between the possible role of the game procedures as media and their role in transforming the players' opinions. We can still add another differentiation between both functions and the real decision-making at the end of the game.

Such distinction is in fact rather theoretical in so far as the persons examined in this type of game don't have generally the power to decide. The objection may be raised that together with the importance in the game, of information and the transformation of opinions there may come some awareness resulting in concrete actions ; but on the contrary it can lead to a conditioning and a handling by the game promoters, who wish to steal the approbation from people playing.

The game may become a substitute for true democracy. The protagonists must bear in mind this basic data. But together with this main aspect, induced effects may sooner or later become important and promote the gradual knowledge of main problems.



It improves, for instance, the relationships of the participants of same status. To practise a game, such as the one we have experimented leads neighbours or parents and children, to exchange mutual information. It also allows an evolution in the opinion of the inhabitants.

It also improves the contacts between individuals of different status : students, architects, inhabitants of the neighbourhood for instance. But friendly relationships cannot erase factors of social distanciation, and the game won't change them either. But it will lead to a clearer appreciation of the parts of each of the people involved. It will let them reconsider the stereotyped and contradictory images of the omniscient technician against the user who has all the knowledge [6].

Moreover, we notice that the control upon the meaning of the choice of activities requires a good knowledge of the psychological and sociological variables of that choice.

It often happens that the choice of an activity does not really correspond to the wish to practise it, but only to the need to have it at hand. In that case, the activity chosen loses its hue of impossibility, that made it so valuable. This happens as we mentioned before, for ballet and piano that often coincide with a longing for better social status.

Another element of distorsion appears with the projection by a few players, of their "leadership", when other participants are younger or less informed about the problems. The choices and requirements may then no longer represent personal aspirations, but what the player thinks he should propose for the others. Or they may correspond to activities he saw or practised in similar equipments.

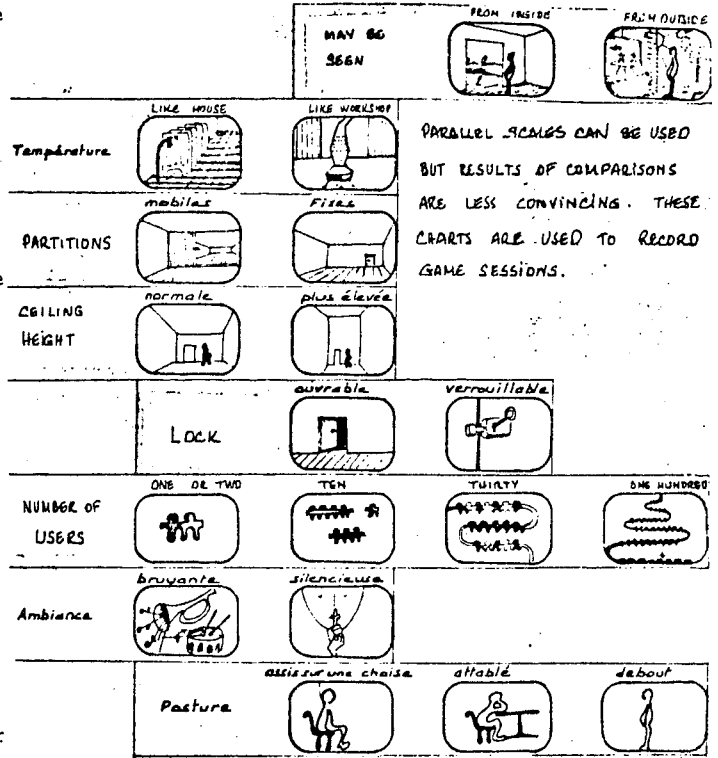
Another ambiguity appeared when we tested the game, because of the presence of architecture teachers, or students. It happened that, confronted to some difficult decisions, some non-technicians asked the technicians : "You decide. After all, it's your job !"

Finally, these remarks stress the opposition that still stands between a technical and formal knowledge that cannot find any concrete social issue, and the feeling of people that cannot express their needs with sufficient precision.

They reveal a dissatisfaction which proceeds from surroundings and from a way of life often unsuited, sometimes unacceptable.

The method we have described brings to the same level designers and future users. They both possess part of the information needed to produce acceptable surroundings.

The question of their respective influence in the realisation of these surroundings, and the means to gain that influence, are beyond the purpose of this paper.



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