

COMPLEX MULTIFACTORIAL METHOD, PRECISE ANALYSIS OF HERITAGE SPECIMENS IN ARCHITECTURE/

Iana-Mihail Codruța - *"Ion Mincu" University of Architecture and Urban Planning, Romania*
kodruyana@gmail.com

Abstract. Complex multifactorial analysis, the acronym C.M.A., is one of the scientific research methods used precisely because of its versatility in many fields. This is an adaptation and extrapolation, set up by me, of two previous research methods: general morphological analysis by Fritz Zwicky, a well-known astrophysicist, and morphological analysis by Bernard Duprat, a professor at Lyon Architecture University. Its versatility comes from the combination of several research methods, starting from the comparative specimen analysis (used in fields such as biology, zoology but also archaeology) up to complex mathematical models, including Boolean matrices (used predominantly in economic fields, of financial-banking analysis or astronomy). The novelty of the work consists in the application of C.M.A. in the theory and study of architecture. C.M.A. results are very precise because they use mathematical methods, and detailed and complex theories can be developed in any theoretical field in architecture based on them.

Multifactorial aspects and structure allow hypotheses from all fields of activity. For example, in the analysis of an architectural style, hypotheses can come from related subjects like history, theory, materials etc., but also different fields, such as sociology, psychology, medicine and so on. This very important aspect is what gives the novelty and complexity of the study.

At any stage of the C.M.A. research we would stop, the results can be remarkable, from the preparation of the specimen collection, to the validated hypotheses or the relationships between them for the most precise conclusions.

Multifactorial analysis and the architectural theory. What we call "architectural analysis" can take on many different meanings in architectural schools and criticism. Often, the term "analysis" is used, without any distinction, to denote any form of investigation, namely simple discussions or comments limited to the judgment of taste, far from a scientific rigour that could bring valid values or hypotheses to light. A description is not enough to phenomenologically characterize the artistic object and never aims to segment them to operate a morphological decomposition. Descriptive analyses, such as aesthetics, for example, do not consider the real structuring of the studied objects, nor the elements that compose them or the way they combine to form the whole, the harmony. The same thing happens with notions like "style" or "current", which often have generalizing and imprecise connotations. These ambiguities of language run counter to the objectivity that rigorous scientific research achieves. That's why we can't confuse description with analysis; they basically have different purposes. The aim of research is

not to criticize or deny but, on the contrary, to discover and understand the values of the respective field.

Apart from our way of understanding what we see, there are other factors that can disturb the perception of an object, like education and visual training with the everyday image. Michelis writes: "we see... because we foresee, we hear, because we first hear within ourselves and, in a word, we correct what appears as imperfect before our eyes... Our emotion is creative. On the occasion of the aesthetic experience we have from the opera, we re-create it according to the spirit and not according to its letter because, through the lines, we read the idea and do not limit ourselves in the least to the sensations that the immobile letters evoke" [1]. Also, Worringer named and studied the introopathy [2], a phenomenon in which man seeks himself in art, finding pleasure in what he already knows and is familiar with. This aspect profoundly influences the process of analyzing art and appreciating it.

Those are some facts that were taken into consideration and conducted for an analysis method whose results are as accurate as precise, beyond appreciation and comments, a method that was named "Complex Multifactorial Analysis", abbreviated C.M.A., who operate with mathematical tools. C.M.A. was set up in the doctoral thesis "Paradigms of minimalist style" to determine if minimalism is a style in itself and not a mannerism of modernism, as is often stated, determining its paradigms [3]. Thanks to his mathematical method of data processing, it was able to circumvent, using C.M.A., any ambiguity in obtaining information so that the conclusions of the doctoral thesis were precise and clear.

C.M.A. is based on the theories of general morphological analysis (acronym G.M.A) developed by Fritz Zwicky [4], astrophysicist, and applied in architecture by Bernard Duprat, professor at the National School of Architecture in Lyon. The process of inventorying, systematizing information and theorizing, used in various scientific fields, such as archaeology or biology, have proven each its own point of view, the final conclusions and hypotheses being pertinent and indisputable.

C.M.A. protocols. There are several steps in this method of research that were established and perfect in the research:

1. Affirmation of the study theme and establishment of some preliminary working hypotheses. The first stage consists of defining the purpose of the C.M.A., respectively, the study theme. In other words, what do we want to achieve with this analysis? The goals pursued by the C.M.A. can be varied, from the preparation of a specialized scientific documentation to the determinations of artistic style, all types of characteristics in any knowledge field. The exact definition of the purpose is very important for the study's results and will coordinate further steps, generating the research theme and, implicitly, the primary hypotheses based on what we know or what we think we already know about the chosen topic. The preliminary hypotheses are derived from what Professor Duprat calls "the state of knowledge" [5], what we already know about the subject in question. These first opinions-hypotheses are essential for the objectivity of the final result, as little as possible influenced by expectations. It is good to know that the state of knowledge helps us to establish the theme,

to start the study, but it can also lead us astray, being able to offer wrong further hypotheses, influenced by prejudices on the conclusions. In other words, the researcher could influence the research results due to his biases. However, a well-designed protocol manages to correct the inaccuracies and give the correct answers.

2. Establishing a collection of objects of the same class and documentation.

C.M.A. works over a collection of specimens that include the most comprehensive totality of pieces (corresponding to the study objectives) that we estimate and select to validate the hypotheses. The collection is established in the first phase according to two criteria:

a. Specimens with the same nominal identity, conferred by their authors or by the specialized literature. Keep in mind that:

- The quality of the research depends on the rigorous choice of specimens from relevant information sources and as valuable as possible in the field in which they operate;

- It is important the margin of error that can intervene at this stage, which will have to be corrected during the analysis.

b. Selecting the specimens according to the hypotheses stated in the previous stage. At this point is important:

- The homogeneity of the collection is established by the common properties from the point of view of the initial assumptions.

- The collection should be large enough to be representative of the research topic.

If, for some reason, we decide to narrow the area of specimen selection, this fact will be mentioned in the research in its final results. The specimens will be placed in attribute tables that will contain all the defining elements of the collection in order to observe if there are certain influences or particularities, differences that could distinguish different currents; in short, all the details that will provide complex data in the research. As the study progresses, omissions of some details may bring inconsistencies in the working hypotheses, risking breaking the coherence. A number of other hypotheses may also come to light, which is natural after a more in-depth study of the collection.

The purpose of this stage is to draw up complete documentation for each specimen of the collection, which will constitute the study material. For a specimen to be registered in a research protocol, a complex documentation is necessary that includes all the studied elements. The analysis result's accuracy depends on the documentation's authenticity. The concretization of this phase is the preparation of documentary files for each specimen, which catalogs all the information. The multifactorial analysis is operated with the help of these files. After obtaining the documentation, it is necessary to order it accurately, in order to be used in the attribute tables. Because when we talk about a certain conformation and refer to a certain homologous segment, the sample brought and introduced into the table is in the form of an image: photos, drawings, concept sketches, etc.

This is not an innovative type of documentation; just as morphological study is not a new methodology. What is innovative is the manner in

which the information is processed. The documentary material on which the subject is studied may contain different fields of knowledge, such as: drawings, plans, facades, sections, authors' sketches, photographs of the buildings made by the researcher or taken from the bibliography, etc. Also, interviews about the studied subjects are taken from quality sources such as specialized magazines or documentaries; bibliographies and specialized monographs showing the creative process and artistic concepts, specialized criticism related to the selected elements of the collection and so on.

The results of the analysis depend exclusively on the quality of the documentary material, so that it will be selected with the most significant responsibility. It is preferable to state in the conclusions of the research that we did not have sufficient documentary material to research a specific hypothesis or theory rather than using dubious documentary material. A possible weakness is that the choice of documentation is made only according to preliminary hypotheses or conclusions we believe in from the beginning, which are subjective.

Once this documentation is collected, the researcher will intrinsically analyse, giving rise to a new set of hypotheses. Together with the preliminary ones generated by the "state of knowledge", these will constitute the complete set of hypotheses that must be validated by the C.M.A.

3. Analysis of the specimen's collection. After the collection has been established and its rigorous cataloguing, the actual analysis will begin, considering the research theme and preliminary hypotheses. The selective collection activities have already begun the research processes, and the perspectives will adapt accordingly. Only now will the researcher correctly intuit and be able to generate pertinent working hypotheses. The conclusions of a C.M.A. can have many ramifications: correlations between elements or between parts of the chosen specimens, complex analyses that determine styles and particularities, or it can simply be cataloguing in order to draw up a perfect database.

The analysis of a collection of specimens in C.M.A. comprises two parts:

a. Morphological analysis studies the forms, their structure and composition, as well as the attributes of these forms: proportions, composition, colours, textures, etc. Morphological analysis constitutes the basis of research in architecture, mainly when we determine or study styles, because their invariants are determined not only by the forms but also by their structure. It is not a new method used in the theory and history of architecture and the arts, being used mainly for the rigour with which it classifies, compares and catalogues documentation from wide areas. Epistemologically, morphological analysis scientifically defines the object as a whole. Morphological decomposition is the disassembly of the components of an object that is considered a stable structure formed by sub-elements. After the theory of Professor Duprat [6], in the specimen tables, the following will be operated:

MORPHOLOGICAL DE COMPOSITION »» COMPARATIVE ANALYSIS BETWEEN ELEMENTS OF THE SAME TYPE »» DISCUSSING AND ANALYZING ANTICIPATED RESULTS

This analysis studies not only the decomposed parts but also their com-

positional relationship. A simple analysis of these forms, be it of theory or the aesthetics of architecture, does not have the power of C.M.A. accuracy to state at the scientific research level, such as defining conclusions for the subject studied. The two approaches of decomposition and comparison support each other. The result is obtained by comparing specimens, seen as structures, appropriately chosen and decomposed according to their specific properties. The comparison can only be made by examining element by element decomposed with care, in sufficiently obvious and comparable segments, taken from each of the specimens. When we use the term “comparison”, it refers not only to the shape but also to its attributes. The results of this step must be interpreted later with the help of logical operations and calculations.

b. Multifactorial analysis is the research of related information, according to any criterion that contributes to accurate and complex results, criteria corresponding to the research goals. Morphological analysis protocols are extrapolated to non-morphic domains. By categories of information, we can extract and highlight, in the case of architectural study, characteristics such as: colours, amount of light, costs, materials, site, functions, personality of beneficiaries or architects, social categories, psychology or sociology, practically from any related domain of interest. The complexity of the study consists not only in the rigour of the decomposition and classification but also in how these comparisons are interpreted. Each entity is treated interdependently of the others, and its identity emerges by analogy. This is followed by the discussion and analysis of the anticipated results, which consider the state of previous knowledge, the preliminary hypotheses, and the theoretical result of the effort so far. Perhaps only a few of the first hypotheses remain, and as a result of complex analyses, the researcher can generate the main hypotheses that will form the basis of theoretical conclusions on the topic.

4. Working with hypotheses

a. Establishing the hypotheses

The classic definition of a hypothesis is that it is a supposition that is provisionally based on observations and serves to explain some phenomena but which cannot be verified so thoroughly by experience or experiment as to form a theory. The purpose of a hypothesis is to make valid and meaningful predictions about phenomena that have not yet been demonstrated. The only relevant test of the validity of a hypothesis is to compare its predictions with empirical experience. Two concurrent and contradictory hypotheses cannot be supported and predicted, and a deliberation must be made to eliminate the weaker hypothesis and retain the stronger one. The hypothesis is rejected if its predictions are contradicted. According to the stages in which they are generated, there are:

1. Preliminary hypotheses with which the analysis starts
2. Hypotheses taken during the analysis
3. Hypotheses resulting after researching the entire collection

b. Table of hypotheses validation

After establishing the hypotheses, the information will be grouped into

ordering tables to verify how each specimen validates the respective hypothesis. The table will contain complete information for the research, from the name of the author and the project in the collection, the location of the site and function, quantitative and qualitative characteristics. The conclusions of these tables consist of detecting the validated hypotheses, respectively, depending on the number of specimens: unvalidated, weak, medium, and strong. The unvalidated hypotheses will be eliminated from the following stages, and the weak ones, if only verified by a few specimens, will also be eliminated.

c. Formation of sets of elements that validate each hypothesis.

Each hypothesis has a sum of specimens that validate it and will be transformed into a set of elements to which an acronym will be given.

d. Boolean matrix

The relationships between the sets of specimens corresponding to the hypotheses cannot be obtained by trial or empirical observation; instead, they can be obtained by entering them into a Boolean matrix that can accurately determine the above information. This solution is suitable in cases where the hypotheses, especially the specimens, are in large numbers, so establishing these relationships becomes impossible without a computer tool. These will perform calculations that will study the following types of relationships:

COMMON ELEMENTS - the sets of specimens have common properties, and which are they

DISJUNCTION - which sets are disjoint, meaning they have no element in common

BELONGING - what sets contain or belong to other sets

CONGRUENCE - which sets have the same properties

e. Analyzing the given sets from the point of view of the element contained and the relationship between them.

Let's take an example and apply the method to it. It is about a small collection of ten constructions by Alberto Campo Baeza, which are chosen to see how a few hypotheses are validated. In the table below, we'll find the data collected from the previous tables of data for every specimen. The pictures are only informative but not representative or enough to determine the validity. The hypotheses are:

I1- use of rough materials: concrete

I2- simple, prismatic volumetric composition

I3- lack of decorations

I4- presence of stereotomic tectonic dialogue

I5- existence of a podium

I6- contrast effect in the visual dialogue with the surrounding environment

Let's analyze the given sets:

I1: (L1, L2, L9)

I2: (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10)

I3: (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10)

I4: (L1, L2, L9)

I5: (L1, L2, L6, L9)

I6: (L1, L4, L5, L6, L7, L8, L9, L10)

At first glance, it can be observed that hypotheses I2 and I3 are very powerful, having all the specimens included. That makes them specific for the collection and characteristics that define it. Also, they are identical or congruent. This means that all the specimens that present I2 (simple, prismatic volumetric composition also have I3 (lack of decorations). The same conclusions for I1 and I4 are congruent: all the collection specimens with rough materials (concrete), also present a tectonic composition.

C.M.A. conclusions. From interpreting the relations in the Boolean matrices, the architectural theories can be subtracted with specific and exact conclusions. A relational scheme will be drawn up to understand exactly the type of relations between the sets of specimens that respect the same characteristics. The conclusions of this scheme are interesting, considering that they belong to a field of knowledge of architectural theory, the information being obtained on mathematics. This aspect is what makes the use of C.M.A. in the analysis of style unique, for example.

It will be exemplified by commenting on a few relations in the example above.

1. Hypothesis Validation:

I1 and I4 are validated by the same specimens (L1, L2, L9). This suggests that these two hypotheses, while perhaps worded differently, fundamentally address the same architectural characteristic. The same evidence supports them.

I2 and I3 are validated by a broader set of specimens (all L1-L10). This indicates that hypotheses about simple and prismatic composition and lack of decorations are more general or encompass a wider range of architectural styles or implementations. All the available evidence validates them. Again, do not forget those rules are applied only to this collection.

I5 is validated by L1, L2, L6, and L9. This hypothesis shares some validating specimens with I1 and I4 (L1, L2, L9) but also has a unique validator (L6). This suggests I5 (existence of a podium) might be related to I1 (simple compositions) and I4 (tectonic dialogue) but also addresses a distinct aspect.

I6 is validated by L1, L4, L5, L6, L7, L8, L9, and L10. This hypothesis is validated by a diverse set of specimens. It overlaps with the validating sets of I2/I3 (L4, L5, L6, L7, L8, L10), I5 (L6, L9), and I1/I4 (L1, L9). This suggests that I6 (visual contrast with surroundings) might be a higher-level or composite hypothesis related to several others.

2. Hypothesis Specificity:

I1 and I4 are more specific hypotheses. Only a small subset of the specimens validates them. They likely address very particular architectural

characteristics: rough materials and tectonic dialogue.

I2 and I3 are more general hypotheses. All the specimens validate them, suggesting they describe more common or fundamental characteristics.

I5 and I6 have intermediate specificity. They are validated by a moderate number of specimens, indicating that podium or contrast effects are neither overly specific nor entirely general.

3. Relationships between Hypotheses:

I1/I4 are related to I5. They share validating specimens, suggesting some overlap in their descriptions of characteristics.

I1/I4 and I5 are related to I6. Again, shared validating specimens suggest a relationship. I6 (contrast effect) seems to be a more encompassing hypothesis.

I2/I3 are related to I6. They also share several validating specimens.

4. Specimen Analysis:

L1, L2, and L9 are key validating specimens. They validate a large number of hypotheses, suggesting they represent architectures that exhibit several important characteristics.

L6 is a particularly interesting specimen. It uniquely validates I5 (podium), suggesting it has a specific characteristic that is not captured by the other hypotheses as strongly.

The table of relationships allows us to understand which hypotheses are essentially the same, which are more general or specific, and how they relate to each other based on the architectural specimens that support them. This analysis can be used to refine the hypotheses, identify key architectural characteristics, and understand the relationships between different architectural styles or implementations.

The analysis will examine each reaction between the sets in this way, determining the characteristics of the collection or invalid hypotheses. It will also mathematically determine the hypotheses that are less valid but strong enough to become characteristics of the collection. After the number of specimens that validate the same hypotheses, we can make subcollections of objects that can determine, for example, influences in an architectural style, by geographical region, culture, trend sets, etc. Also, precise determination and conclusions can establish precise style invariants and abbreviations, as well as the appurtenance of buildings of style or artistic current.

C.M.A. can be utilised in any of its stages. One can create excellent documentation for any subject and also compile a precise collection for any research by using the initial protocols for making documentation sheets, tables, and charts. The study of Boolean relations establishes the exact characteristics of specimens, as well as the excluded ones and the correspondence between them.

Here is how, by detaching ourselves from simple observation and the methods of aesthetic appreciation, with the help of this mathematical way of analysis, the theoretical parameters for describing the studied collection will be obtained in the smallest details. Starting from structuralist thinking, the final conclusions are obtained through a phenomenological interpretation of the creation process, thanks to variables from all fields of knowl-

edge and interest for research. The corroboration of the results of each field involved, makes the conclusions complex and objective, eliminating as much as possible the relativity of the judgment of taste. The innovation and usefulness of C.M.A. lies in the fact that we can adapt these protocols to the purpose of our research. Any of the stages will be useful for an in-depth study.

References.

1. Michelis P.A., Estetica arhitecturii, (Meridiane, București, 1982), p.317
2. Worringer, W, Abstracție și intropatie (Univers, București,1970)
3. Iana, C. Paradigmele arhitecturii minimaliste (PIM, Iași, 2014)
4. Zwicky, F., Discovery, Invention, Research through the Morphological Approach (CAL Tech, California,1969).
5. Duprat B., Paulin M., Le système de la façade&de la baie: maison a loyer urbaines du XIX siècle, (HAL open Science, Lyon, 1995)
6. Duprat B., Paulin. M., Les types de l'architecture traditionnelle des Alpes du Nord. Maisons. (HAL open Science, Lyon,1989)

Tables.

TABLE 1 - Hypotheses validation.

TABLE2 - Boolean relationships.

Figures.

FIGURE 1 - steps in this method of research that were established and perfect in the research;

FIGURE 2 - hypothesis levels.;FIGURE 3 - L1- Caja General De Ahorros, Granada, Source: https://commons.wikimedia.org/wiki/File:Edificio_CajaGranada.jpg

FIGURE 4 - L2- BIT Center, Source: <https://www.flickr.com/photos/campobaeza/>

FIGURE 5 - L9 - Villa De Blas Source: <https://www.campobaeza.com/blas-house/>

FIGURE 6 - L6 - GARCIA MARCOS HOUSE, Source: <https://www.flickr.com/photos/campobaeza/>

Table 1, Hypotheses validation

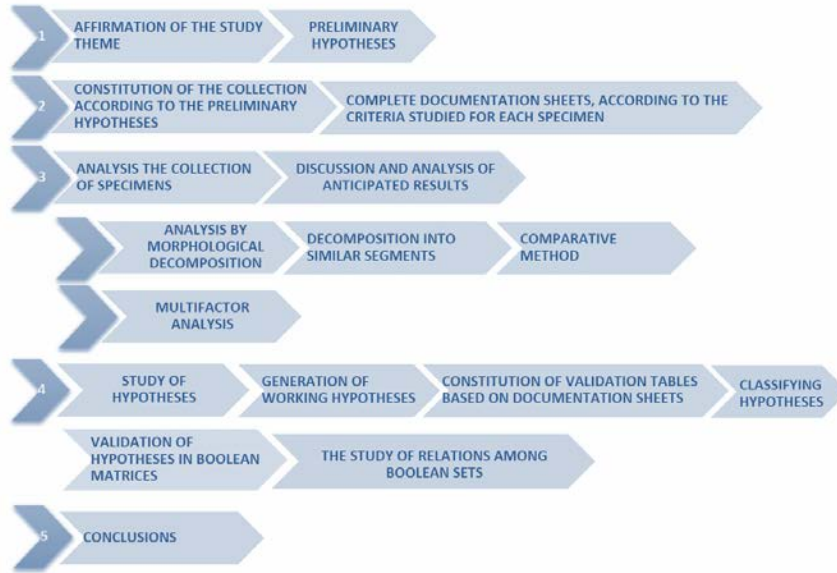
| Ln/ SPECIMENS | Hypothesis | | | | | |
|---|------------|----|----|----|----|----|
| | I1 | I2 | I3 | I4 | I5 | I6 |
| L1/ CAJA GENERAL DE AHORROS, GRANADA | • | • | • | • | • | • |
| L2 SEDIUL BIT | | • | • | • | • | |
| L3 DRAGO PUBLIC SCHOOL., CADIZ | | • | • | | | • |
| L4 GASPAR VILLA | | • | • | | | • |
| L5 TUREGANO HOUSE | | • | • | | | • |
| L6 GARCIA MARCOS HOUSE | | • | • | | • | • |
| L7 BENETON CHILDERN HOUSE | | • | • | | | • |
| L8 GUERRERO HOUSE | | • | • | | | • |
| L9 VILLA DE BLAS | • | • | • | • | • | • |
| L10 ASENCIO HOUSE | | • | • | | | |

Table 2, Boolean relationships

| RELATIONSHIP | DESCRIPTION | SETS INVOLVED |
|--------------------------------|--|--|
| Subset (\subseteq) | I1 is a subset of I2 and I3. I4 is a subset of I2 and I3. | $I1 \subseteq I2, I1 \subseteq I3,$ $I4 \subseteq I2, I4 \subseteq I3$ |
| Not Subset ($\not\subseteq$) | I1 is not a subset of I5. I4 is not a subset of I5. I5 is not a subset of I2 and I3. I6 is not a subset of I2 and I3. | $I1 \not\subseteq I5, I4 \not\subseteq I5,$ $I5 \not\subseteq I2, I5 \not\subseteq I3,$ $I6 \not\subseteq I2, I6 \not\subseteq I3$ |
| Equality (\Rightarrow) | I1 and I4 are equal. I2 and I3 are equal. | $I1 = I4, I2 = I3$ |
| Intersection (\cap) | $I1 \cap I2 = I1 = I4; I1 \cap I3 = I1 = I4; I1 \cap I5 = I1 = I4; I1 \cap I6 = \{L1, L9\}; I2 \cap I3 = I2 = I3; I2 \cap I5 = I5; I2 \cap I6 = I6; I3 \cap I5 = I5; I3 \cap I6 = I6; I4 \cap I5 = I1 = I4; I4 \cap I6 = \{L1, L9\}; I5 \cap I6 = \{L1, L6, L9\}$ | $I1...I6$ |
| Union (\cup) | $I1 \cup I2 = I2 = I3; I1 \cup I5 = I5; I1 \cup I6 = \{L1, L2, L4, L5, L6, L7, L8, L9, L10\}; I2 \cup I5 = I2 = I3; I2 \cup I6 = I2 = I3; I3 \cup I5 = I2 = I3; I3 \cup I6 = I2 = I3; I4 \cup I5 = I5; I4 \cup I6 = \{L1, L2, L4, L5, L6, L7, L8, L9, L10\}; I5 \cup I6 = \{L1, L2, L4, L5, L6, L7, L8, L9, L10\}$ | $I1...I6$ |



1.



2.

