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THE JOY OF SYNTAX

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Abstract: The article describes an approach to teaching syntactical aspects of design and architectural composition by means of exercises utilizing various computer graphics programs. The theoretical assumptions and the background of formal studies are reviewed as sources of this approach. A working definition of Architectural Knowledge and Design Knowledge is postulated as the theoretical foundation of Computer-Aided Learning. The term, Architectural Syntax, is proposed as the formalization of this knowledge. The pedagogical significance of computers as a medium of design education is analyzed, and the particular role of syntactical knowledge in design, the computation of design and in CA.L. in design is identified. An outline of the course, The Joy of Syntax, is described and future research and development in these fields discussed.

1. Introduction

This paper describes a structured program for teaching architectural design through the study of a subject which we term, *Architectural Syntax.* In this program the computer is employed as an environment in which to learn the principles of architectural design, the knowledge of which once gained, may be applied either within, or without, the computer. Our work attempts to exploit the unique characteristics of the computer as a medium for conveying knowledge of the format aspects of architectural design and of the generation of designs. The purpose of the paper is to explicate some of the theoretical background of this approach, as well as to describe the teaching method.

We consider this work as part of a contemporary tradition of formal studies. As an introduction, and in order to describe the theoretical foundation, we provide a brief historical sketch of this background. The purpose of such courses differs from other educational goals of CAD studies in that they explicitly address one of the main goals of the architectural curriculum, teaching design. In this respect, we see our work as part of an effort at various institutions throughout the world which is changing the nature of design teaching. Among this is the work of Mitchell, Stiny, and Liggett at UCLA and Harvard; of Flemming, Schmitt and Akin at Carnegie Mellon; of Kramel and Schmitt at TH Zurich; and of Radford at the University of Adelaide. The change is from design teaching with a problem orientation to design teaching with a *knowledge orientation* In this method of teaching *design knowledge is the explicit content of the teaching approach.* What is common to all of this work is the focus upon *formal knowledge as* seminal among the complex types of knowledge which *enable design.* Furthermore, there is a general acceptance of the importance to both design and design computing of the explicit and rigorous definition of formal representations and design operations. The rise of this new generation of syntactic studies in design coincides with the blurring of traditional boundaries between the design studio and the computer laboratory, and most of these people teach design and design theories as well as design computation.

The present course profits from the experience of several pilot programs in the Computer Aided Learning of design which were initiated at the University of Sydney and the Technion. The materials which were developed for the pilot courses (Oxman, Radford, Oxman, 1987) dealt with plans and planning. The present course attempted to address the concept of a *general theory of form in environmental design* which we term, Architectural Syntax. Experimentation with the *teaching of architectural syntax as the content and through the computer as an enabling technology* were among the goals of this work. A comprehensive text on Architectural Syntax is currently in preparation (Oxman, Radford, Oxman).

2. Designs and Designing

2.1 Knowing Designs and Making Designs

Any theory of design education must be founded on a theory of design. Implicit in the theory underlying the work described in this paper is the assumption that designs are

intermediate objects which are symbolic representations of the artifacts to be produced from them. Designing requires the knowledge to *describe* (including representational formalism and annotational technique) and the ability to *manipulate formal representations of designs.* Design is the manipulation of these intermediate objects through various forms of transformations. We consider the acquisition of this knowledge to be among the goals of design education.

Learning design is acquiring knowledge of the classes and techniques of the representation of design objects (formal representations) and of the structuring and operating upon these representations in order to achieve a design in a specific problem context. Design is also goal and value motivated and there are many additional types of knowledge which are applied in the processes of generating, analyzing and evaluating designs. However, we consider that the *knowledge of formal representations underlies the generative aspects of designing.* It is fundamental to all of the complex phenomena which we refer to as designing. We have proposed a working definition of *Architectural Knowledge as* the knowledge of the representations of architectural and urban formal artifacts and of *Design Knowledge as* that knowledge which *integrates classes of object descriptions with operative procedures in designing* (Oxman and Oxman, 1989). Obviously designing involves other knowledge as well, including evaluating and interpreting, or giving meaning to, forms. But purely on the basis of formal generation, we can conceive of design as *processes and operations performed upon formal descriptions.*

2.2 Design Knowledge and Design Learning

Such a theoretical approach presupposes an integral relationship between the knowledge of designs and the knowledge of designing. "Knowing design" is dependent upon a *particular kind of knowledge about designs.* For convenience, this may be thought of as knowledge of precedents. But knowledge in design is generalized and abstracted, the knowledge of generic classes of object descriptions. Prior knowledge in design is generic knowledge gained through study and experience (Oxman,1989). This is not necessarily prior knowledge of solution space, but generalized prior knowledge of a typological nature as well as knowledge of design heuristics and formal manipulative, adaptive and transformational procedures.

Essentially different from the conventional derivation of historical precedents, *formal knowledge* emphasizes the generic, and consists of the formal principles which are characteristic of various historical periods despite apparent stylistic dissimilarities. It establishes a deep level of knowledge of design descriptions in a generic, abstracted form which identifies the salient formal principles. At the level of syntactic analysis, this is knowledge of what formal entities constitute designs, how they have been composed, how they may be decomposed, refined, modified and adapted. Design is enabled by the understanding of these formal principles which are embedded in the representations of designs and operations upon these representations. Learning design is seen, in this interpretation of design knowledge, as *learning to represent form and learning to operate upon classes of representations* in order to make other, or even to create new, designs.

Design learning has been defined here as the acquisition of well formalized structures of architectural and design knowledge, including formal object descriptions and transformational processes, as well as heuristic procedures. From recent teaching experience, it appears that this knowledge can be conveyed very effectively. We can simulate sophisticated design behavior on the part of students by teaching a limited range of formal representations as *stylistic languages* in which approach the student learns to "generate form" relative to this language, by mastering the descriptive representational conventions and formal manipulation intrinsic to the specific style, or formal language. This is a phenomenon characteristic of design teaching in various schools of architecture in which concepts of formal language are employed to explore stylistic interest in a particular formal or compositional approach. But the real purpose of such studies is much broader: it is possible to convey general knowledge of design rather than the limited goal of teaching a range of languages in order to explore form or to simulate design proficiency. We view the teaching of the classes and principles of representations and operations of Architectural Syntax as *a source of knowledge* of environmental design. But until integrated with other kinds of knowledge such as interpretive and evaluative knowledge, each of which has an important role in design, formal generation must be considered simply one of the important components in the knowledge-rich environment of designing.

3. The Formalization of Design Knowledge

3.1 A Brief History of Formal Studies: the Derivation of Architectural Syntax

Various terms such as *morphology*, *basic design* and *composition* have been employed historically to describe the study and definition of the formal principles of design and the formal classes and principles of configuring space and material in the making of architectural and urban designs. We use the term Architectural Syntax to convey a significant change in orientation of the studies in the contemporary period. The history of the development of this approach and the significance of the linguistic analogy, with its emphasis upon *rigorous syntactic description as underlying design generation is* described briefly below. Collectively we may employ the term *composition* to describe the formal aspects of designing and syntax as the rigorous, scientific definition of the principles of and operations upon form in architectural and urban design.

The Classical Tradition is the major historical source of formal principles and syntactic definitions in Western Architecture (Tzonis and Lefaivre, 1986). Within this tradition, various theoreticians and architects such as Alberti and Palladio have placed particular emphasis upon the definition of formal principles as a source of professional knowledge and a basis for praxis. Architectural history has many examples of treatises which attempt to formalize the knowledge of form and composition. The Ecole des Beaux Arts was one locus of such theoretical production, and there as at other French institutions, theories of composition were developed. Durand created an approach to formal knowledge and the role of formal knowledge in the generation of designs; it is an example of a formalization of

syntactic knowledge carried to the level of a theory of designing (Mitchell, 1989). This is, of course, part of a more general rationalistic development in 18th and 19th Century continental theories and practice in which geometrical order, formal principles and compositional rules play an important role.

A recurrence of interest in these subjects in the contemporary period may be said to begin with the work of Wittkower on Renaissance theory (Wittkower, 1949) and writings of Rowe on formal analysis (Rowe, 1947, 1963). During the period of the 50's interest in configurative studies began to be of general importance both in practice and in architectural research. The Cambridge School of researchers and the Martin Centre played a major role in the development of a modern approach to formal studies and to our understanding of the role of formal knowledge in design and design computing. Their work demonstrated the use of a mathematical basis for precise formal descriptions and the mathematical modeling of environmental form and process. Among the pioneers in this field are Lionel March, Philip Steadman and Bill Hillier. The work of Stiny, Mitchell and others on Shape Grammars (March and Stiny, 1984; Stiny, 1980; Stiny and Mitchell, 1978) is one of the sources of a contemporary approach to *syntactic analysis* (Oxman and Oxman, 1989). This scientific work is part of a general interest in the *formal analysis* of designs (Baker, 1984). The explication of formal knowledge and the role of syntactical knowledge in design generation are among the main themes of design theoretical activity from the period of the 60's until today. Linguistic theory, particularly the work of Chomsky, has been a significant factor in this development for both designer theoreticians and design researchers; and during this period there has developed an increasing importance of formal categories and formal grammars and languages as a result of the application of a *linguistic analogy* to Architecture.

What should be noted in this historical sketch is that there has emerged a *new epistemology* of architectural knowledge in which the formalization of syntactic knowledge through the study of precedent is disassociated with stylistic eclecticism. The formalization of Architectural Syntax is a source of architectural knowledge and a foundation of design. Today the goal of developing this knowledge is a common concern of a large body of the international design community including the fields of design, design theory, research, education and computation.

3.2 What Is Architectural Syntax

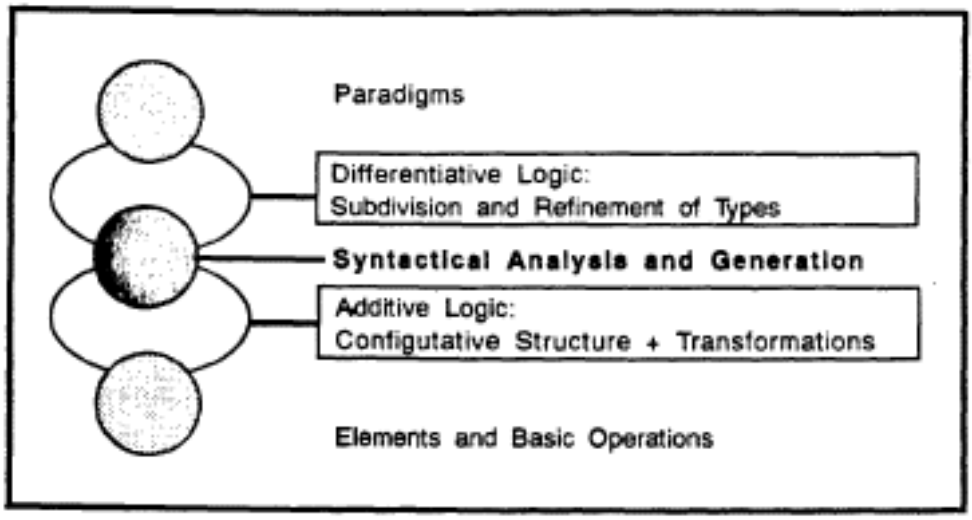
Two related approaches to formal descriptions have emerged from the background which we have described. The first, which we term Formal Analysis defines a vocabulary of architectural formal categories including organizational and compositional categories. Generally, formal analysis includes graphical description analysis. Architectural Syntax may be considered a sub-class of Formal Analysis. Syntax is the study of descriptive representations and formal generative processes and their relationships. It's content is the scientific analysis and description of the object types and the additive, subdividing, refinement and transformative processes of formal generation. It is the rigorous description of form and formal relationships which makes formal generation possible through operations performed upon syntactic representations. That is, architectural syntax has an

implied goal of achieving a level of representations which is rigorous in the mathematical sense, and which can be employed *both in the analysis and generation* of architectural and urban forms by operations performed upon these formal representations in order to create designs. Thus the nature of syntactic representations is that they are not only analytically descriptive, but also capable to operate as the material of formal generation. Chomsky's work in linguistics (1957,1965) and Stiny's (1975, 1980) work in Shape Grammars are among the sources of Architectural Syntax; Eisenman's design and theoretical work (1987) has demonstrated one of the important characteristics of the syntactic: the synthetic power of the analytical.

According to the definition which we have proposed, the work on Shape Grammars which has been produced throughout the world since the early work of Stiny (1975) and Gips (1975) is currently the major body of work in Architectural Syntax. The term Architectural Syntax attempts to suggest the possibility of a *General Shape Grammar*, that is, the formalization of general knowledge of the principles involved in the syntactic aspects of environmental form and languages of form. In such an extension of the root concepts underlying Shape Grammars, we would also suggest that the shape grammar formalism, rich in descriptive potential, tends to prejudice towards the description of form as *sequential additive configurations.* Architectural Syntax would seek to broaden this practice to include both of Stiny's descriptive paradigms (Stiny,1976), (Mitchell, Liggett, Tan 1989), as well as new work on the classification of compositional and transformational strategies. A *general syntactical language of environmental form* might also necessitate the further development or adaptation of existing descriptive formalisms.

An additional source for Architectural Syntax is compositional studies. Syntax is essentially composition, or the formal principles underlying the definition of the formal elements and the principles of relationships of material and spatial elements. The idea of an Architectural Syntax extends the traditional interpretation of composition in that among its theoretical sources are the current emphases upon formal representations as well as contemporary concerns with typology, formal structuring and transformational procedures. The *annotation of designs,* how we physically note designs, and the logic underlying the representation and representational formalisms are the two main methodological aspects of syntactic study.

We are currently working on the definition and classification of syntactic knowledge in Architecture and Urban Design. A simplified model of syntactical knowledge is presented. In this hierarchical model of syntactical knowledge, both top-down holistic knowledge and bottom-up integrative and configurative processes are considered to complement one another.



Syntactical Knowledge: Top-Down and Bottom-Up

3.3 The Joy of Syntax: the Role of Syntactical Knowledge in Design Generation

The *joy of syntax* derives from the role which we have postulated for syntactical knowledge in the processes of design generation. This is the generative capability which is the result of gaining knowledge of composition which is syntactic. That is, knowledge of the formal representations of designs. The joy of syntax is a generative capability provided by syntactic knowledge. Here design generation is seen as selective routines performed upon designs as object representations. This also reflects certain current design theoretical interests in the role of syntactical knowledge as a design vehicle beyond conventional compositional logic (Eisenman, 1988, Tschumi 1988).

4. The Pedagogical Role of the Computer in Design Studies

4.1 Knowledge in Design

According to the theory of knowledge in design which we have outlined, knowledge resides in the intermediate objects which represent designs; in the generic character of that knowledge; in the knowledge of how to represent design objects in order to be able to operate upon them in design; as well as the knowledge of the processes, operations upon and transformations of form which produce designs. We have postulated that there is a meaningful structure to this knowledge in design such as the hierarchical structure proposed above, and that this structure probably has cognitive significance (Oxman 1989). Syntactical knowledge is the essence of design, and if it is possible to formulate this as a body of theoretical knowledge, it must also become the explicit content of design teaching. The problem is that Architectural Syntax does not yet exist as a well-formulated body of knowledge. But there are growing indications that we know how to build rigorous

object descriptions, such as Shape Grammars and languages of design, that we are beginning to develop *general languages of design* (Flemming, 1989) and are beginning to classify the complex operations which designers employ. Despite the lack of scientific formalization of syntactical knowledge in design, the approach has given some indication of promise with respect to design education. It renders design teachable within the framework of its definition of object descriptions and classes of manipulative operations.

4.2 Knowledge in Design Computing

Architectural knowledge is an *implicit form of knowledge* in design. The ways in which we describe form in order to deal with it during designing is not necessarily apparent in the final design or in the building. *It is in design computation that these representations and operations become explicit and the processes, routines and nested operations of composition become transparent.* Knowledge resides in the electronic processing of form rather than in the formal results. Learning what and how to represent in order to achieve a particular result, the operations on formal elements and representations which results in compositions, and what kinds of computational operations produce classes of formal entities, this knowledge is in the nature of computer graphics programming and design computation (Mitchell, Liggett, Kvan, 1987, Mitchell, 1989). The appropriate representations of syntactic knowledge is one of the theoretical foundations of design computing. It is interesting to observe that in the work of certain architects such as Eisenman and Fujii, representation of syntactic processes upon form are now also becoming part of the content of final representations in design.

4.3 The Computer as an Environment for Teaching Design

The seminal role of formal knowledge to design and design learning (March and Matela, 1974) can be exploited in an approach to design learning in which the computer provides a unique pedagogical environment for design studies. Since the computing of design makes explicit object descriptions and the operations upon objects which make designs, it is an effective environment for teaching the principles of designing. Working in the computer environment on the logical structure of architectural composition and design generation is an effective means of learning the principles of design generation by observing and controlling formal operations and electronic formal processing. From an educational point of view, learning to understand the programming and processing of form is more significant than the graphic, or design, product. The logic of the selection of formal elements, the graphic processing operations and the principles of composition are immediately observed. This is the case when working in graphic applications, such as in the Macintosh environment, as well as in graphics programming.

The computer is a vehicle for effectively teaching the formal representational logic and the implications of this logic of representations for the resultant potential of creating designs within that logic. Design knowledge as we have defined it can be acquired through the interaction with design computing. As Stiny has pointed out, this is dependent upon the existence of a well-defined body of formal knowledge (Stiny, 1976). Thus, there is a need for an Architectural Syntax. But even on an *ad hoc* basis, the computer and computer graphics programs function as a medium for the formalization and acquisition of design

knowledge through specific architectural examples. Eventually we believe that designers who are capable of formal manipulations within a computer environment will employ the computer in an interactive relationship in which design generation through design computation is part of a design partnership relationship with computers.

5.The Joy of Syntax: An Approach to the Syntactical Study of Composition through Computer Graphics

5.1 Teaching Syntax

In this section we describe the course which we have developed for the teaching of architectural design through a structured sequence of seminar - exercise modules and work in computer graphics. The emphasis of this course is on the syntactical study of the composition of architectural form. The purpose of the course is an introduction to Architectural Syntax and provision of experience of the role of syntactical knowledge in the design process. As in our previous work, the computer functions as a teaching medium and a self-learning environment as well as the tool which produces designs. We have previously experimented with the medium as a vehicle for teaching about the characteristics of plans and the nature of the planning process (Oxman, Radford, Oxman, 1987). This study program has now been employed several times at the Universities of Sydney, Adelaide, the Technion and elsewhere, and has been an effective and promising medium for conveying knowledge of design in a rich and remarkably articulate manner. These courses which convey the design theoretical content in an explicit manner, are conceived of as supplementary to design studio projects. The work has been documented in a teaching text and the experience analyzed in various papers (Oxman, Radford, Oxman, 1998, 1989).

The present course is a pilot program for a second generation of such work. It was an attempt to reconsider the potential of CAL (Computer-Aided Learning) in design studies with the benefit of our experience and that of others (Kramel, et alia, 1987) and to identify certain directions for development. The content of the program was to include the beginning of a *formalization of disciplinary knowledge* (Oxman and Oxman, 1989) and the course was an experiment in teaching such knowledge. The concept of *an architectural syntax,* of a well-formulated vocabulary of syntactic elements and operations, seems to us an essential form of disciplinary knowledge in Architecture. In the process of the current course, we have experimented with these concepts without the prior development of a comprehensive architectural syntactic vocabulary, a work which we are currently in the process of developing.

Composition, long unfashionable for its formalist connotations, has in contemporary design and design theory become a meaningful subject of inquiry. An additional goal of the program was to introduce some of the richness of the subject of contemporary composition and to introduce the student to power of the computer media in dealing with the subject of the composition of designs.

The course is based upon the learning of the syntactical and compositional aspects of design through the interaction with computer graphics programs. A planned sequence of exercises is designed to enable the student to gain design knowledge by "doing design" through the analytical and generative operations which make designs. It is in the exploration of the computer and the logic of formal processing in computer graphics programs that there occurs the acquisition of design knowledge. In the interaction with graphics programs in the representation of the formal objects as formal elements and in the processing of these elements to make designs that the student gains the knowledge of design. He gains insight into the construction of complex formal objects such as plans and elevations as well as the operations underlying their construction. Part of this derives from the process of formalization of particular aspects of architectural knowledge as elements of a design language. Formalizing designs as design elements or design languages and by sequences of operations with the computer becomes a means of accessing design knowledge. The structuring of knowledge in the computer builds a structure of knowledge in the student-designer.

This is consistent with Flemming's interpretation of design as a form of computation, that is, a sequence of operations being performed on a symbolic representation of the objects being designed (Flemming, 1989). Learning the methods of formal representation, the sequences of characteristic operations which generate compositions, understanding the formal processing capability of the computer provides a knowledge-rich learning environment for the study of architectural composition. The medium thus teaches by the interaction with graphics programs or, the "computational advantages of the medium are used to understand design in terms of the designed object" (Akin, 1989).

5.2 Introduction to the Course

The course was run on a weekly basis including seminar - lecture sessions in which the subjects of Architectural Syntax were presented and discussed. During these sessions the weekly exercise was presented which explored one aspect of the current subject. A second purpose of these sessions was to review and discuss the previous week's work which was presented informally by the students through print-outs. Subsequent to the discussions, we adjourned to the computer lab to work with the students. The number of students was limited by the availability of computers. We used the Mac II of which we had five available for various courses at the time. There were ten students who took the course in addition to their regular studio design work. Half had no previous computing experience and none of them had previous experience with the Macintosh. Instruction in using the computer as well as an introduction to the graphics programs was provided as part of the course. Studies lasted a full semester of fourteen weeks, with meetings once a week and each exercise period being approximately two weeks.

Part of the objectives of the program were to analyze the teaching / design potential of a new generation of Macintosh graphics software. Though not yet dedicated software for *architectural formal processing*, it provides a sophisticated range of operations upon form, much expanded from the first generation of Paint/Draw programs. We experimented with the application of Superpaint 1.1 and Canvas 2.0 to the teaching of syntax. Superpaint

was used as an introductory program providing both Paint and Draw operations with two layers. Certain facilities such as rotating, nudging, reversal of figure-ground were utilized in the early exercises. We moved for most of our work to Canvas 2. which provided a much more sophisticated range of formal processing capabilities as well as an unlimited number of layers. These programs limited us to two-dimensional analysis and design. We had originally intended to introduce two additional programs, including a simple 3-d program and a color program. However, the exercises required considerable time, and it was decided to limit the number of graphics programs used. We are currently experimenting with the teaching possibilities of Mac Architrion and Hyper-Card and hope to employ a larger range of tools in future programs.

5.3 The Joy of Syntax : Themes and Exercises

Themes

1. Syntax of Architectural Objects

The Eisengram, or Homage to the Square

2. Syntactical Operations

The Decomposition and Recomposition of Architectural Objects

3. Syntactical Structure

Ordering Principles and Rule Systems Underlying Composition and Formal Languages

4. Compositional Style

Layering and Superposition in Cubism

5. **Syntactic Analysis of Complex Compositional Systems**

Compositional Strategies in Post Modem Space

6. Post Compositional Design

Annotational and Representational Aspects of Deconstruction

Themes and Exercises

1. Syntax of Architectural Objects

Introduction to Architectural Syntax.

Architectural elements; syntactic elements; geometric systems. The concepts of vocabularies.

The specification of object descriptions and operative processes on form.

Partitioning. The subdivision of the Platonic solids. Classic syntactical divisions versus decorative partitions. Classic partitions and architectural syntactical archetypes (e.g. Nine-square; Four-square).

Homage to the Square. The square and its architectural partitioning. "L" and grid relationships within the square.

Exercise: *The Eisen-gram, or Beyond the Tan-Gram*

The exploration of the syntactical properties of the square as a basis for the development of an architectural puzzle. Explore formal processing in the computer.

2. Syntactical Operations

The concept of operations on form. Introduction to symmetry operations as a class of operations. Form Writing and the vocabulary of architectural operations.

Sequences of operations. Nested operations.

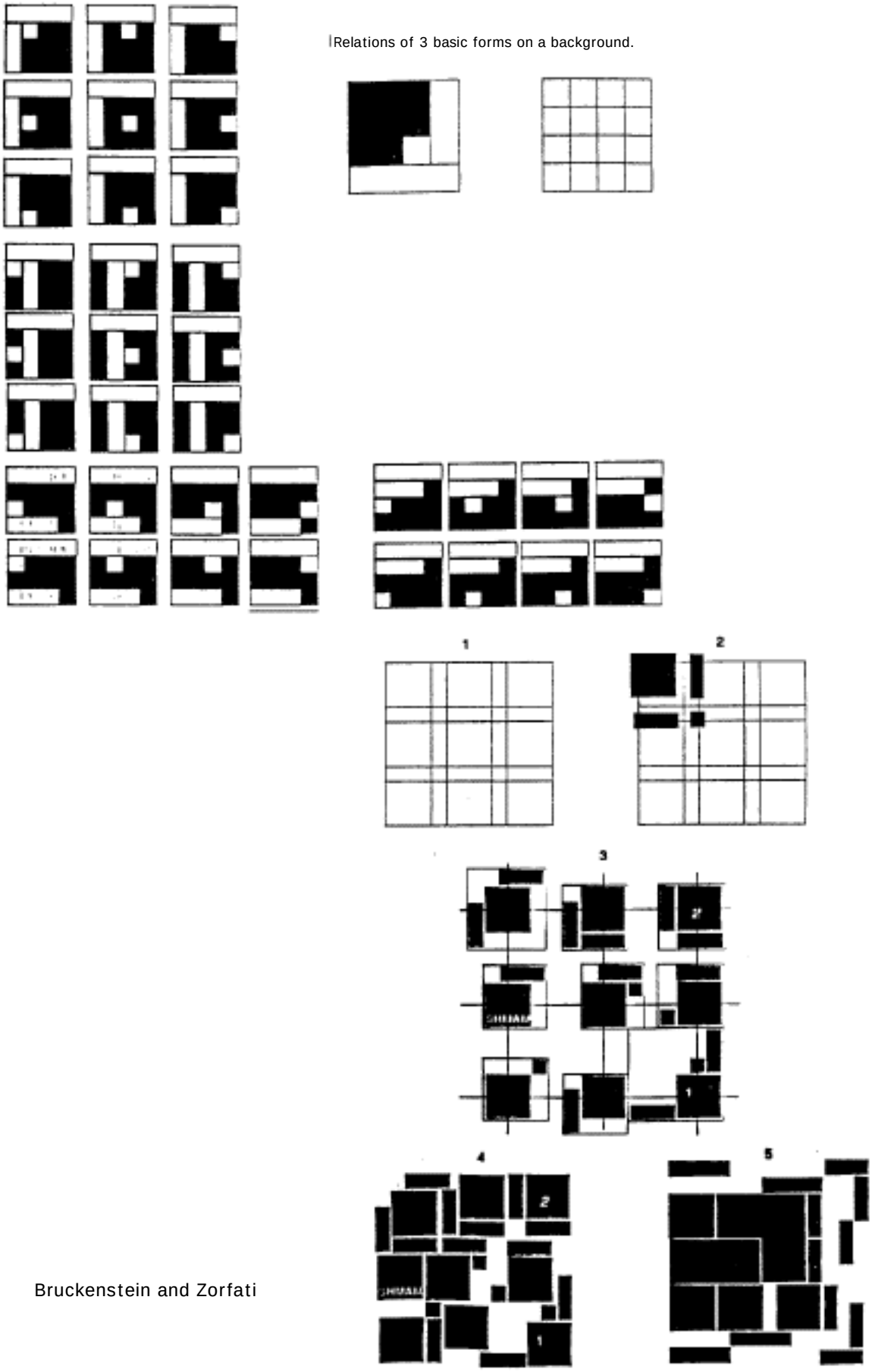
Parametric variations. Scaling. Transformational procedures. Spatial set operations.

A vocabulary of formal relationships: disjoint; corner-adjacent; face adjacent; intersecting; coincident; sub-joint.

A vocabulary of architectural transformational processes: accretion; subdivision; erosion; substitution; shear; shifting; replacement.

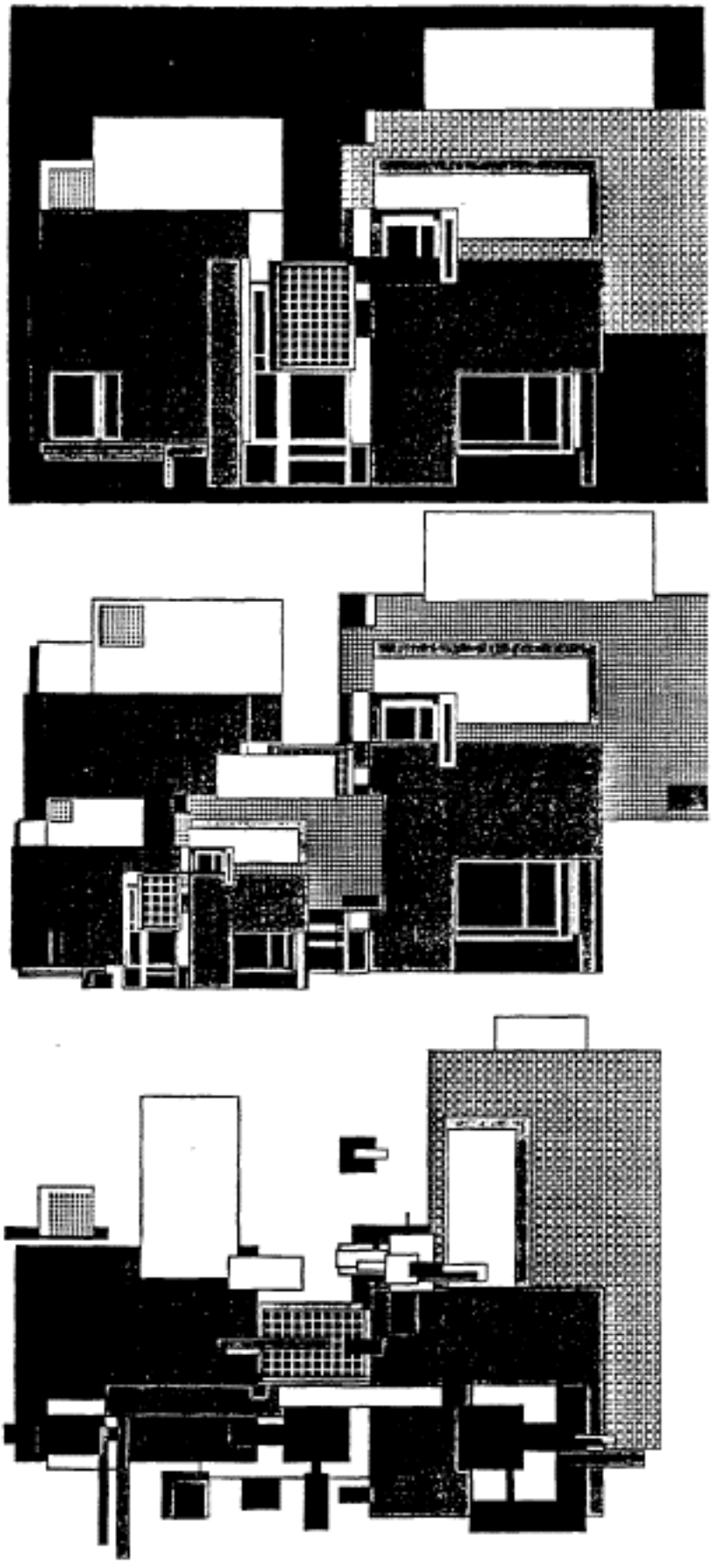
Exercise: *The Decomposition and Recomposition of Architectural Objects*

Decompose a compound or complex architectural object such as a plan whose form has been the result of the definition of an architectural vocabulary of elements and a sequenced procedure of composition. Document the vocabulary of elements. Re-construct the form, classifying the operations of composition. Explore an alternate sequence of operations upon the same formal vocabulary.



Exercise 1. The Eisen-Gram: An Architectural Game

Exercise 2. Decomposition - Recomposition of an Elevation by Eisenman
Zorfati



Exercise 2. Decomposition - Recomposition of an Elevation by Eisenman
Zorfati

3. **Syntactical Structure**

Introduction to rules and to languages of form.

Intermediate abstractions. Structure, ordering principles, and rule systems which underlie compositions and formal languages.

Classes of structuring devices: axes, grids, modularity, zoning, etc. Relationships of form to intermediate abstractions.

Classes of rules and rule systems. Rule-building: top-down versus bottom-up. Recursive rule systems. Nested rules and procedures.

Aggregative principles and rule systems.

Exercise: *The Syntax of the Village, a Hierarchical, Aggregative, Recursive Language of Form*

Establish a vocabulary of elements for the basic unit. Develop a rule system for a language of form of variations. Develop an ordering system for a hierarchical ordering of clusters, neighborhoods, etc. Illustrate variations at each hierarchical level. Identify principles of compositional ordering at macro-scale of the village and compare two principles.

Explore the formal processing capacity of the program to modify or reprocess designs.

4. Compositional Style

The study of composition and the analysis of compositional style. Compositional approaches. Strategies and mechanisms of composition. Current interest in composition in design, theory and design research.

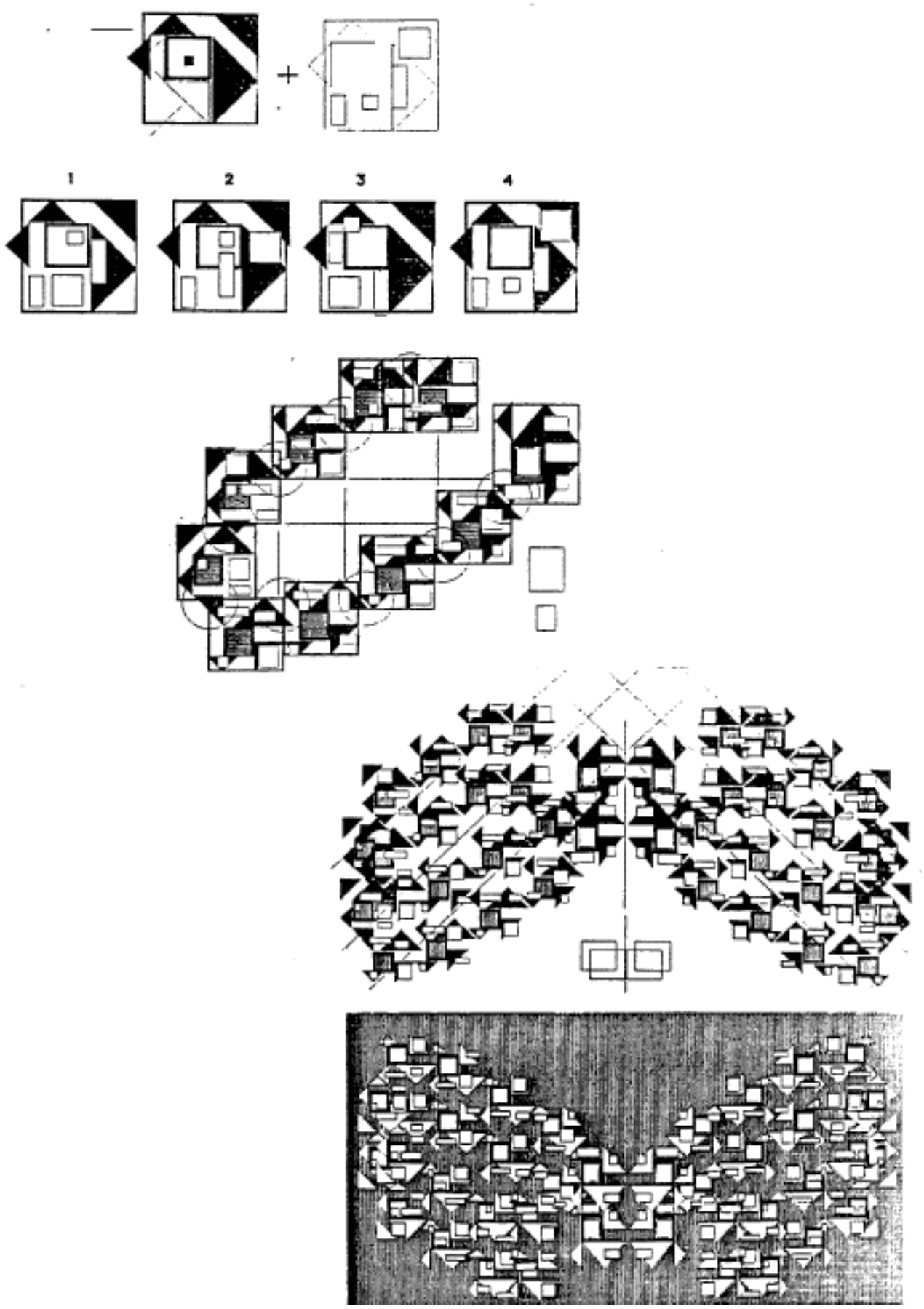
Layering and Superposition in Cubism and their architectural implications. An analysis of the formal characteristics of Cubist paintings. Some characteristics of superposition. Collage and montage: philosophical and applicative aspects.

Layering, superposition and Cubist "shallow space". The Cubist paradigm in architectural "readings" (formal interpretations) of deep structural diagrams. Coloring of deep structure. Plan notations in layered space.

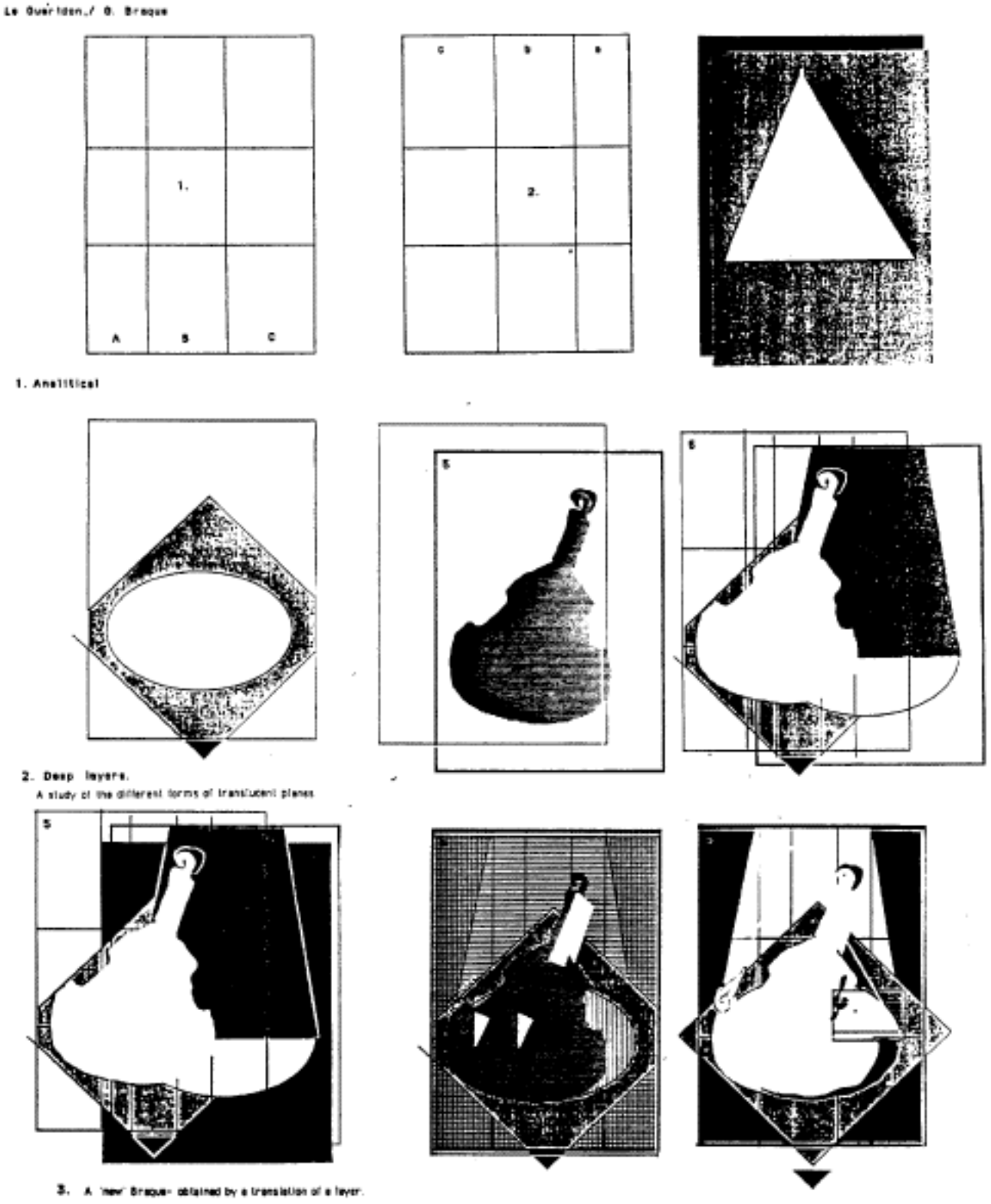
Exercise: *Layering and Superposition in Cubism: the Syntactic Analysis of a Cubist Painting*

Identification of the vocabulary of elements, compositional structure, strategies of composition in a Cubist painting.

Decompose the painting by layers, employing the layering capacity of the program. Recompose with modifications of electronic processing. Explore emergent forms.



Exercise 3. Syntactical Structure: the Formal Language of the Village
Zorfati and Efrat



Exercise 4. The Syntactic Analysis of a Cubist Painting
Zorfati and Levitan

5. Syntactic Analysis of Complex Compositional Systems: Compositional Strategies in Post Modern Space

Aggregative and differentiational logic in formal descriptions. Their interaction in designs: top-down and bottom-up.

Unitary compositional structure versus compound and complex structures.

Layering, zoning, ambiguity and boundaries in Post Modern Space. The new composition. The classification of compositional strategies.

Formal and syntactic categories in plans. Representation and annotation of form for composition in plans.

Reading and writing architecture

Exercise: *On Reading and Writing Plans - a Syntactic Analysis of Meier's Museum in Frankfurt*

Analysis of the plans as a layered Cubist composition. Identification of macro and micro compositional principles. Multiple superimposed vocabularies of forms. Figurative and configurative vocabularies.

Analysis of a plan by layers and vocabulary elements. Identification of compositional strategies: shear and skew, etc.

Exploration of variations within the language of form.

6. Post Compositional Design: Representational and Annotational Aspects of Deconstruction

The idea of Post Compositional Design as beyond unitary structures. Highly transformational compositions. The vocabulary of architectural transformational strategies.

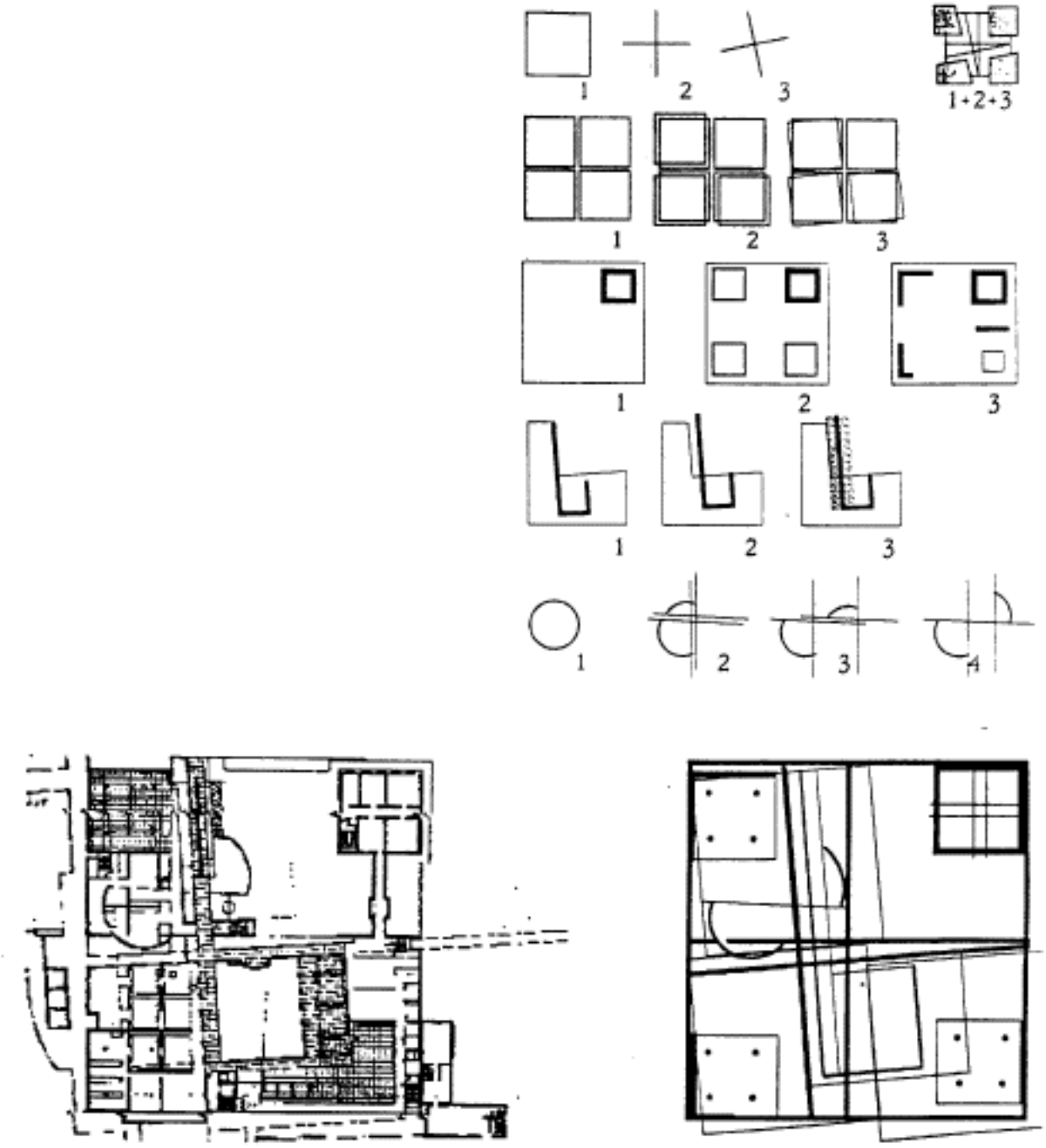
Deconstructional readings of form as transcendent formal interpretations.

Annotational and representational aspects of Deconstruction. Experimentation with notational systems.

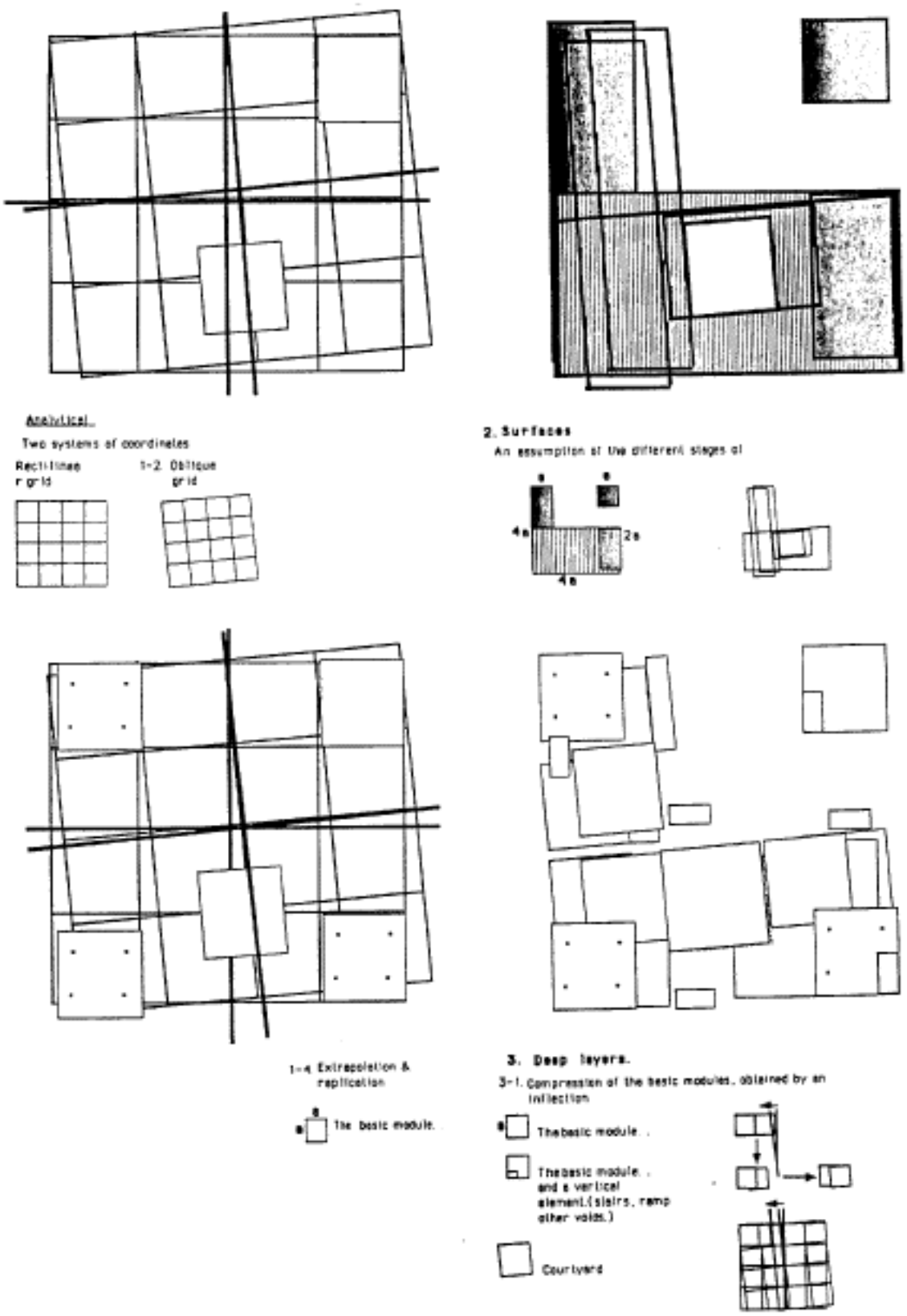
Recording of transformational operations and traces of intermediate processes in final representation.

Exercise: *Analysis of Contemporary Architectural Work: Exploration of Deconstruction as a Method of Formal analysis and Composition*

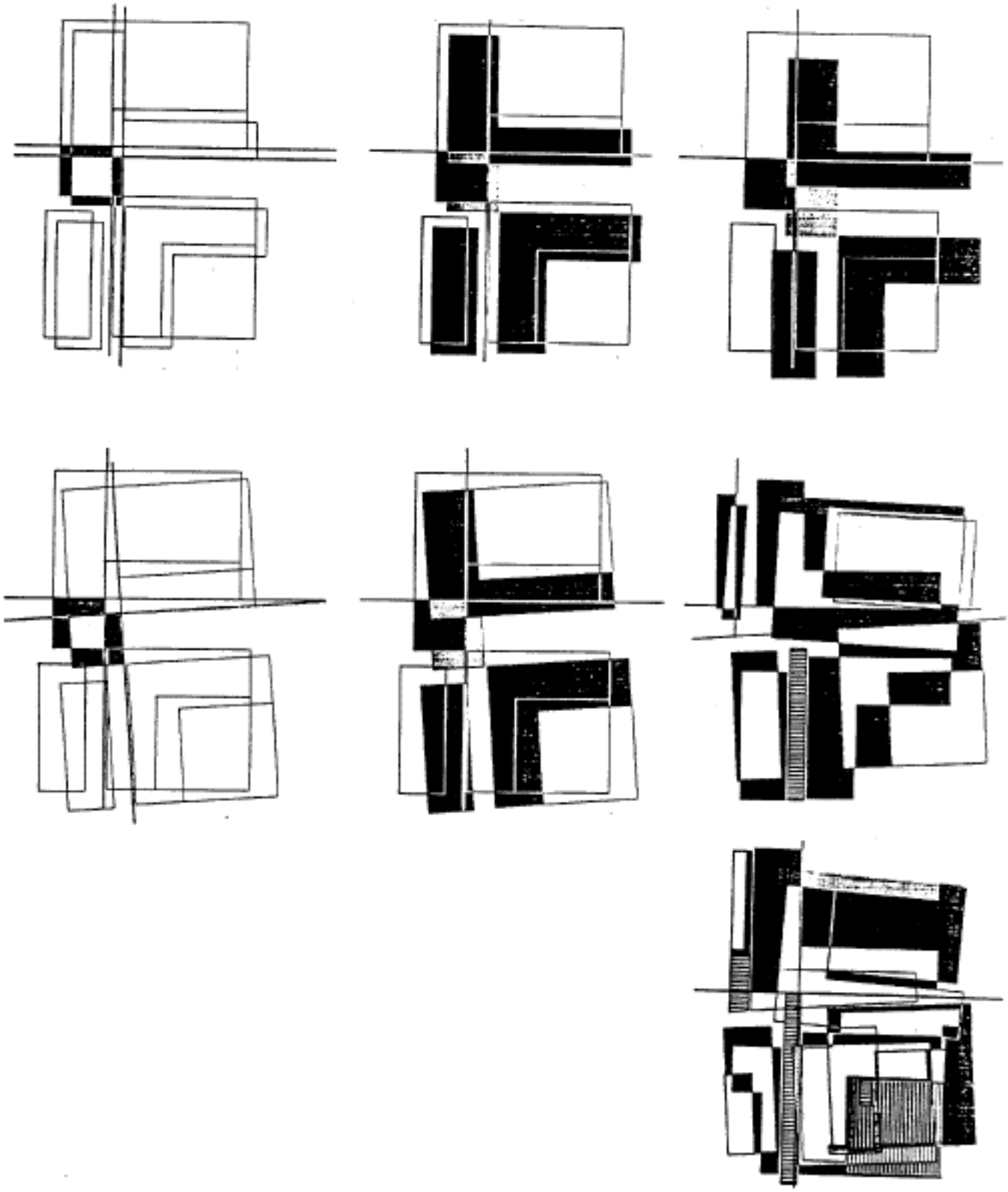
Perform syntactic analysis. Re-do as Deconstructional analysis. Apply various new strategies of composition and transformation, such as strip transformations, shifting, and scaling.



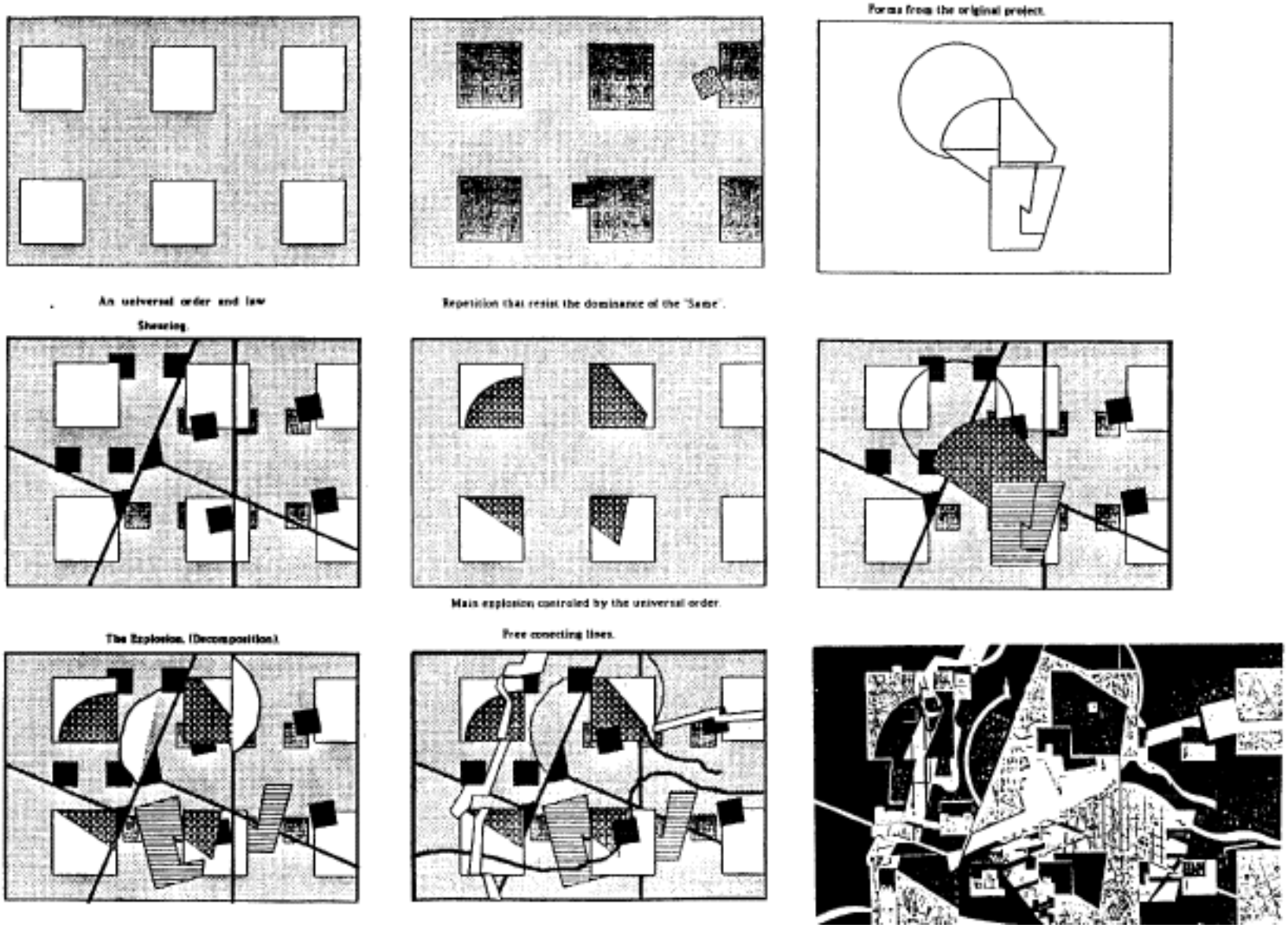
Exercise 5. Syntactic Analysis of Meier's Crafts Museum Frankfurt
Rapoport and Shayovitz



Exercise 5. Syntactic Analysis of Meier's Crafts Museum Frankfurt
Levitan



Exercise 6. Experimentation with a Representational System of Eisenman
Zorfati



Execise 6. Experimentation with a Representational System of Eisenman
Bruckenstein

6. Conclusions

The further development of the course is dependent upon the formalization of the body of knowledge of Architectural Syntax. We are preparing a comprehensive work on the subject and future generations of this course should be more structured and comprehensive in content as this material is incorporated in the teaching program. Furthermore, we expect to use three-dimensional software in the future work and to include the study of three-dimensional syntactical relationships such as architectural massing.

Even lacking this material in a rigorous and comprehensive form, the study of a sophisticated range of formal questions through the interaction with a new generation of graphics software has been a stimulating and intellectually rewarding experience for the student. The inter-relationship of compositional processes and computational procedures has been illuminating. Work in the computer has enhanced the level of compositional experimentation even with complex compositional structures which are laborious to deal with in hand drawing. Syntactical studies show promise of revolutionizing design teaching, and the computer is beginning to prove an effective *pedagogical environment* for this new generation of design studies. The formalization of this body of knowledge, architectural syntax, is part of the theoretical foundation of design teaching as it is of design computing. Future generations of students who have been trained in design thinking and in design generation in the computer will naturally continue to exploit the compositional and design generative capability of the computer in their professional lives.

Perhaps the most suggestive and promising potential of this experimental program is the validity and power of thinking and designing with syntactic structures. The possibility of a "computer-trained imagination" (Mitchell, 1984) is further strengthened by establishing the compositional rationale of the interdependency of formal analysis and generative capability. The integral relationship of analysis and generation, so central a theme of current design, is fundamental in syntactical study. The Joy of Syntax is the increased capability to understand and control formal generation which comes of learning syntax through computational study. Through analysis the student-designer defines a vocabulary of formal elements, syntactical relations and the operations which will process the forms electronically into designs. It is in this process that the secrets of architectural composition can be elucidated through computer graphics education and an understanding of the generative power of analytical process is gained.

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