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Computer Grammars for the Syntactical Analysis of Paintings

HOW do we, as informed viewers, recognize an example of an artist's work, a piece we have never seen before? We probably carry in our collection of visual memories, usually in some inarticulate fashion, a knowledge of formal regularities that an artist typically displays in his work. It is the syntactic nature of the work that we notice: the quality of lines, colors, shapes and their arrangements. We recognize paintings by what we see, not by what they mean. For example, we are little inclined to recognize a face by Modigliani or Soutine because one is serene and one is tortured (semantic qualities), but rather because each has a noticeably different technique for drawing and painting. Moreover, the way an artist treats a range of plastic opportunities, albeit handmaidens of meaning, will be his most enduring personal stamp. It is these plastic (syntactic) qualities, which can be expressed as a grammar, that we will address and explain in this paper.

Art historians, philosophers, and teachers of art and design have long heeded the analogy to language and grammar in art. The terms usually are loosely or metaphorically applied, however, and with less specific notation than we propose. Naturally, it is writers who tend to formal criticism who point to "languages of art." Most notably, Wöfflin[1] defined styles by his well-known dichotomous descriptions, although semantic insights tend to infuse his syntactical boundaries. Gombrich[2] posits that artists are confined to a body of inherited schemata in realizing their work. Kandinsky prophesied that "the progress won by systematic work will create an elementary dictionary which, in its further development, will lead to a 'grammar' and, finally, to a theory of composition which will pass beyond the boundaries of the individual art expressions and become applicable to 'Art' as a whole."[3] Masters of De Stijl obeyed strict tenets of composition, though, like Kandinsky, spiritual values are embodied in their formal orders. Members of the Bauhaus, such as Gyorgy Kepes,[4] spoke of the fundamentals of image making as a language with normative rules. More recently, Thomas Munro[5] has persuasively argued for a dispassionate scientific approach that would classify art morphologically. He sees art better understood through a universally acceptable notation that could be applied to a systematic analysis and synthesis of styles, both in form and content. Ackerman[6] realizes that styles of painting refer to cogent abstractions of certain techniques and processes, rather than to their expressive qualities. Erle Loran's[7] approach, of course, has been the most specific in his formal graphic analysis of Cézanne's compositions. And the list goes on.

However, the work of Curtis Carter[8] comes closest to our own pursuits. While many people suggest an affinity between art and language, Carter unfolds a "language-like" system for art for which we think grammars could be developed as descriptions of style. Words are the syntactic units in a verbal

language, and rules for using them are exemplified in sentences. Similarly, shapes, as defined by color, line, texture, or volume, are the fundamental units in Carter's pictorial language; their allowable combinations for a given style are exemplified in paintings. His work is a convincing existence theory. We offer here a constructive theory that puts some of his ideas into operation, although our antecedents are rooted less in art history and aesthetics than in the computer-science fields of artificial intelligence and formal language theory.

Kirsch[9] discussed how the computer-science theory of algorithms (formal procedures) and formal languages was adopted by descriptive linguists in the 1950s for explaining natural language phenomena. This theory was extended by Kirsch[10] to account for pictures and diagrams. Further generalizations by Stiny and Gips[11] were adopted by architects to explain architectural design, as when Koning and Eizenberg[12] exhibited a grammar for the Prairie Houses of Frank Lloyd Wright.

The tools exploited in these investigations were various versions of the particular class of algorithms we call grammars. A grammar is a succinct method of describing the formal structure of an often very large class of phenomena, be they natural language objects, pictures, or designs. As a descriptive tool, a grammar is equivocal with respect to two important functions. A grammar can be used by other algorithms to determine the structure of a particular image within its domain, or it may be used by still other algorithms to generate a large number of instances of that domain. The grammar describes the facts of appearance. It may be used to analyze or synthesize specific appearances.

The use of grammars to account for natural language, computer programming languages, architecture, and design has in recent years progressed so satisfactorily that it seemed sensible to attempt a further step. In Kirsch[9] we actually showed how the structure of paintings could be described with formal grammars.

In building a grammatical description for artworks, it seems suitable to start, as we have, within the twentieth century. Art of our era is nothing if not self-conscious, concerned with its own definition and processes. It should welcome clear explanations. But compared to architecture and design, descriptions for paintings may be much harder to uncover. Sketches, which may or may not exist, do not convey information as precisely and completely as architectural plans do for a building, for example. Generally, the artist leaves fewer cues to his plans than the designer, and the process must often be inferred from evidence in the finished work. Recent art imposes so few conventionalized rules that we must search for the personal rules an artist generates and obeys, which give his work its individual look.

This caveat notwithstanding, the time is ripe for a dialogue between art history and computer science. Consequently, we have developed a prototype computer-based grammar of a large oeuvre of the contemporary painter Richard Diebenkorn. We chose his Ocean Park paintings as a reasonable, but nontrivial, challenge. They span about twenty years and include at least 140 (as of autumn 1985) large-scale works. Within the unity of this series, we see enormous variety, complexity, and ambiguity both in formal and informal facture. Moreover, they relate compositionally (and very likely in content) to Diebenkorn's earlier Abstract Expressionist and figurative periods,[13] which suggest, for further study, that the Ocean Park paintings are variants of his fundamental approach to art making. More specifically, we chose Richard Diebenkorn because it was convenient to begin research with work that was roughly geometric, for clarity of verbal exchange and measurement. And, significantly, his visible pentimenti not only divulge his process but figure strategically in the finished product.

Based on our observation (of original works and color slides) of more than eighty paintings, we can create a syntactic description of their linear composition, which can then be expressed as a picture grammar.[14] We are concerned here with linear facture as the deep structure informing all the Ocean Park paintings. Although transformations and ambiguities, owing to color and gesture, are usually the most immediately noticeable aspect of the paintings, they can be considered surface structure and are not addressed in this grammar.

Building a grammar is certainly not a mechanical task leading to inexorable conclusions, but rather a creative task that codifies and expresses one's understanding of the artist's process—a formalized insight. A few of our observations that found their way into the grammar are worth summarizing:

1. The lines and resulting areas are tightly constrained. Every line ends at another line which eventually touches the edge of the canvas. By discovering their logical sequence, we can ascribe their order of importance in the organization. Pentimenti, partially covered lines, and clear lines all contribute to this final network.
2. Most of the works evolve by recursion, that is, larger structures subsume smaller instances of themselves.
3. Typically, we see a clustering of unevenly spaced lines creating bands along the top or one side. An unbroken band begins the painting. Other bands are interrupted by a line or color change.
4. In some works, the lines are rather widely and evenly spaced, whereas in others there is a contrast between narrow bands and open areas. We account for both kinds of distribution.
5. All compositions include diagonals in opposing directions, either explicit or covered.

The following demonstration of the grammar incorporates these and other points more precisely.[15] We illustrate how an analysis is assigned by the grammar to a particular example of Diebenkorn's Ocean Park paintings. Figure 1 shows the painting to be analyzed, *Ocean Park No. 111*, painted in 1978. The grammar used appears in Kirsch and contains forty-two rules for the linear description of the entire Ocean Park oeuvre. The process whereby the grammar assigns a description to Figure 1 is summarized in Figure 2. There we show a sequence of stages in the analysis, including the initial stage, final stage, and several intermediate stages.

The grammar, which is not detailed here, starts by assigning compositions to one of three categories, suggested by the names "urban," "suburban," and "rural." A commitment to one of these categories influences many subsequent choices provided by the grammar, which will determine organization of the composition as well as dimension and color. A suburban choice is made here. The grammar next provides four alternatives for placing a narrow band at the edge of the composition. Then a set of wider bands are allowed by the grammar. In some cases, the grammar allows a single rule to be applied recursively to produce an iterated effect. This is seen in the fourth stage of the composition where seven vertical bands are produced by the recursive application of a single rule. Subsequent stages of the grammar produce the diagonals and the "ghosted" lines seen in the remaining steps of the process. Altogether, a total of thirty-three steps are required for the production of the final composition from the grammar.

The syntactic constituents of each grammar rule are indicated by small markers on the stages of the composition. In a detailed grammatical analysis, these markers would be labeled with the description of the syntactic category that they denote. These syntactic categories would share labels with others of the same or different styles by larger grammars which would comprehend more extensive sets of paintings. It is important to name syntactic categories, even though that constitutes a minor transgression of strictly formal analysis. By assigning names to categories, we implicitly invoke all the semantic baggage that names carry. A more pristine analysis would use abstract distinguishable symbols to name the syntactic categories. We avoid the issue here by merely pointing to the syntactic constituents in Figure 2 with unlabeled markers. But ultimately we must give names to the formal grammatical constituents to provide hooks for carrying them in our machines and minds.

As we have seen, a grammar is an explanatory mechanism. The scholar who has insight into the structural compositional process can express this insight in the form of a grammar. Then, by a mechanism such as we have illustrated, this insight may be exhibited by algorithmically analyzing

the corpus of paintings that the grammar purports to explain. But the same grammar used for analysis can also be used for synthesis. Instead of searching in the grammar for applicable rules to produce a target composition, as we did to produce Figure 2, we can use the grammar in an unconstrained way to produce random compositions. That is, random choices are made among the options allowed by the grammar. As such, these new synthesized compositions are useful in testing the grammar. Such tests are important since a grammar is written by someone who very likely has seen only a limited number of works in that particular style. But the grammar, in attempting to account for the style, as such, is a predictive theory which necessarily goes beyond the available evidence to nonextant compositions exhibiting the same style. Random generation allows us to see these further examples of the style accounted for by the grammar.

We see in Figure 3 such a random generation from the grammar. It does not correspond to any of the known Ocean Park series of paintings, although it bears a strong resemblance to *Ocean Park No. 126*, painted in 1984. To produce this composition from the grammar, a series of eighteen rule applications was used. Figure 4 shows another such random generation significantly different from that of Figure 3, but also subsumed by the grammar. It should be clear by now that an unlimited number of "pseudo-Diebenkorns" could be created this way. A mechanical (algorithmic) process for generating these examples will produce plausible examples, such as those shown here, but it might also produce absurd degenerate cases which are too sparse or have too many recursions (repetitions) of structural elements. However, a reasonable definition of the style that is the aim of the grammar cannot exclude these degenerate cases except under penalty of being ad hoc.

Thus far, our grammar accounts for Diebenkorn's linear composition and, though it seems to strike at the heart of his structure, color is just as important to him and probably carries the weight of his content. Our own work on color is still exploratory, since we have not seen enough original paintings at one time. While reproductions are adequate for seeing linear divisions, they are quite unsatisfactory in portraying color, which is extremely complex. At the moment, we are analyzing color and its application from a group of twelve recent Ocean Park paintings exhibited together in November 1985.[16] This is probably not sufficient to validate the whole series, but the method may elicit further investigation.

One might well ask how computers figure in the making and running of a grammar. Thus far, not at all. The design, analysis, and synthesis have been done "by hand," though based, of course, on theories from computer science. However, only with a computer program would it be reasonable to analyze or synthesize a great number of works. Furthermore, as we go on to explain painting more completely, we must deal with the connections among such components as color, shape, texture, position, and so forth. The complexity of integrating several grammars and demonstrating their interdependence can only be handled by a computer.

Even though we have isolated one manageable aspect of some very sophisticated paintings, this method could serve for examining other aspects. We chose line as the basic structural element for Richard Diebenkorn; for another artist, the obvious starting point for a grammar might be color (e.g., Hans Hofmann) or shape (e.g., Joan Miro). These fundamental properties would be more complicated in the beginning because they would have to be algorithmically defined before serving as the basis for a grammar.

We hope it will occur to the reader that we offer a Diebenkorn grammar as a prototype for raising larger questions that transcend the syntactic confines of one artist's idiosyncrasies. Under the aegis of the patient art historian, questions of content and meaning could, with this approach, be clearly defined and even answered. It is fairly straightforward to codify formalist terms such as space, position, hue, even rhythm, balance, or movement. But other terms that typically illuminate art history, such as lyrical, sensuous, monumental, tragic, and so forth need to be scrutinized for precise definition if they are to be harnessed to a grammatical description. If such a task were undertaken, we could expect a sharper examination of influences, affinities, concordances, and of whole periods and styles. Significantly, as we were reminded by Kandinsky, such encompassing application of formal descriptions could eventually reveal some universals of creative activity. Finally, the clarity of a gram-

matical approach would allow art historians, and anyone interested in visual art, to communicate unambiguously in sharing their understanding.

We in no way mean to suggest that a syntactical grammar captures one's personal relationship to a painting. We have had to suppress, for this study, our overwhelming attraction to all of Diebenkorn's work; we are still awed by his ability to transmit the aura of light, air, space, and architecture of his western landscape. William Rubin has said, "If a work comes at you with everything it's got all at once, you can't not be aware of all the psychological or the poetic or all the other aspects, and you can't separate them from the structural aspects of the work."[17] For now, we have arbitrarily separated a "structural aspect." Perhaps this approach, however, will someday explain, with many integrated grammars, how a work "comes at you with everything it's got."

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NOTES

1. Heinrich Wölfflin, *Principles of Art History* (New York, reprinted from edition of 1929).

2. Ernst H. Gombrich, *Art and Illusion* (New York, 1969), chap. 5.

3. Wassily Kandinsky, *Point and Line to Plane* (New York, reprinted from edition of 1928), 83.

4. Gyorgy Kepes, *Language of Vision* (Chicago, 1944).

5. Thomas Munro, *Form and Style in the Arts* (Cleveland, 1970).

6. James Ackerman, "A Theory of Style," in *Aesthetic Inquiry: Essays on Art Criticism and the Philosophy of Art*, M. Beardsley and H. Schueller, eds. (Belmont, Calif., 1967).

7. Earle Loran, *Cézanne's Composition* (Berkeley, 1947).

8. Curtis Carter, "Painting and Language: A Pictorial Syntax of Shapes," *Leonardo* 9 (1976), 111–118.

9. Joan L. Kirsch and Russell A. Kirsch, "The Structure of Paintings: Formal Grammar and Design," *Environment and Planning B: Planning and Design*, vol. 13, no. 2 (1986).

10. Russell A. Kirsch, "Computer Interpretation of English Text and Picture Patterns," IEEE Trans. Electronic Computers, EC 13:4 (August 1964), 363–376.

11. George Stiny and James Gips, *Algorithmic Aesthetics, Computer Models for Criticism and Design in the Arts* (Berkeley, 1978).

12. H. Koning and J. Eizenburg, "The Language of the Prairie: Frank Lloyd Wright's Prairie Houses," *Environment and Planning B*, 8 (1981), 295–323.

13. Robert T. Buck, Jr., Linda L. Cathcart, Gerlad Nordland, and Maurice Tuchman, *Richard Diebenkorn* (New York, 1980).

14. Carter (1976) considers shape intrinsic to image description. We certainly could have viewed bounded spaces as the units of another kind of analysis, but Diebenkorn starts his work by a trial of lines. Since we are interested in capturing his process and progress, it makes sense to begin with drawing instead of shapes as the earliest stage.

15. This grammar is based on works completed by Diebenkorn by 1980. At his Knoedler exhibition in New York in November 1985, we noted a few additions to his basic "vocabulary," such as the incursion of curved lines. These changes will be reflected in a future refinement of the grammar.

16. *Richard Diebenkorn* [exh. cat., M. Knoedler and Co., New York, 1985].

17. Calvin Tomkins, "Sharpening the Eye," profile of William S. Rubin, *The New Yorker*, November 4, 1985, 52–76.

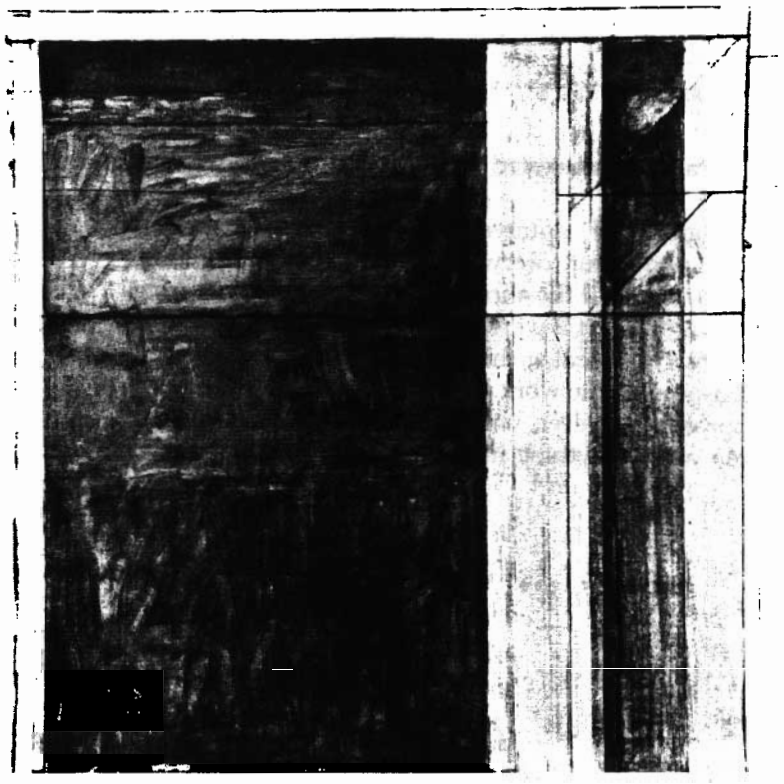

FIG. 1. Richard Diebenkorn, *Ocean Park No. 111*, 1978, Oil and charcoal on canvas, 336.2 × 336.7 cm. Courtesy Hirshhorn Museum and Sculpture Garden, Smithsonian Institution

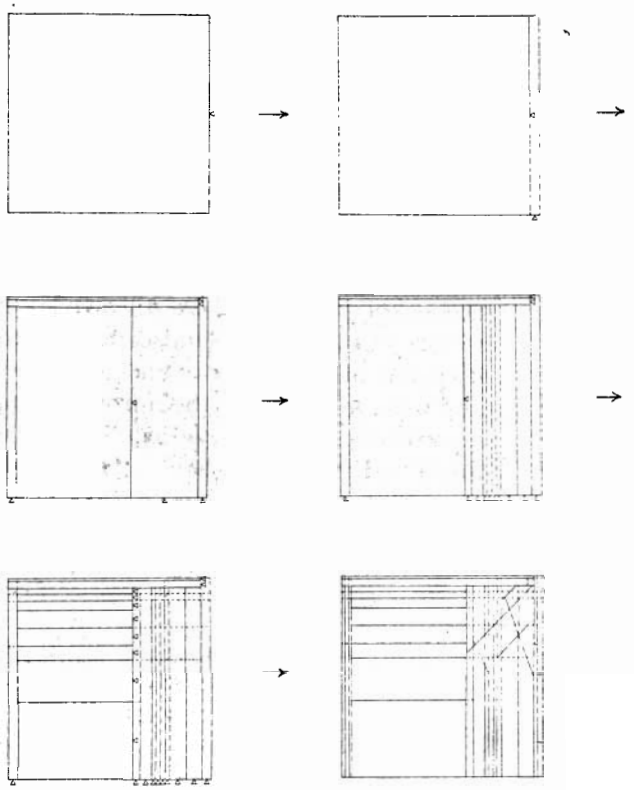

FIG. 2. A grammatical derivation of a composition

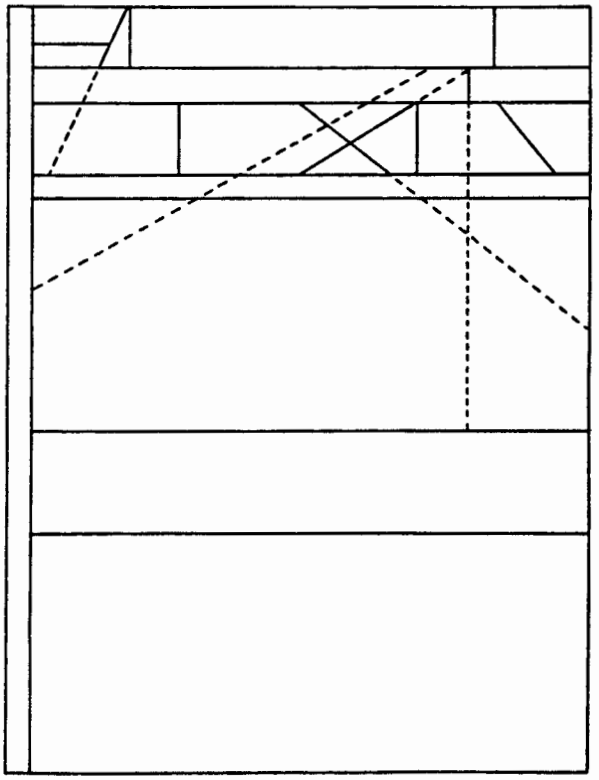

FIG. 3. A random generation of a composition from the grammar

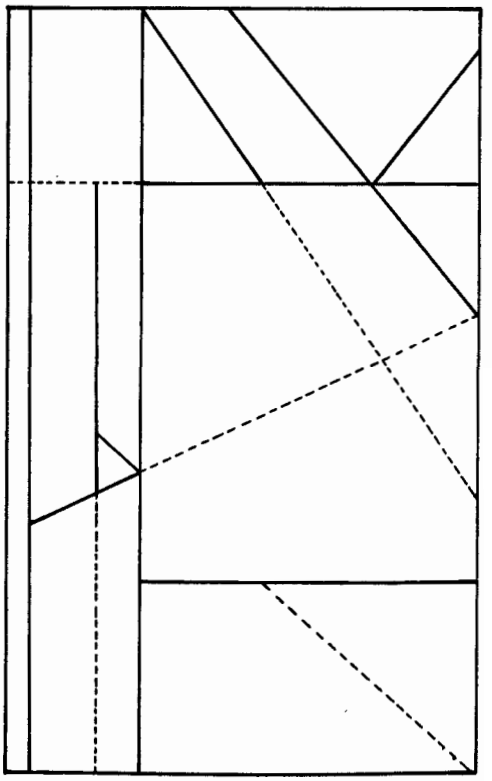

FIG. 4. A random generation of a composition from the grammar