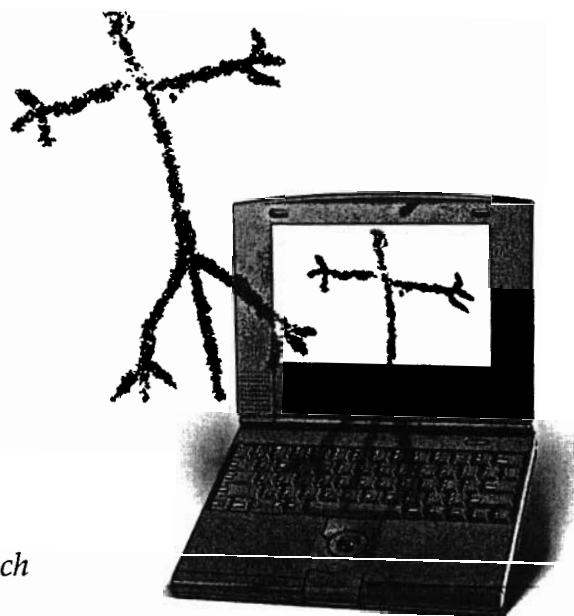


Using Computers to Describe Style



Russell A. Kirsch

Human beings have a poorly understood ability to recognize patterns in their environment. Sometimes this ability is vital to survival. Sometimes it is the enabling ability that mediates the creation and maintenance of a culture. Thus we have art. But always this ability to organize the visual world of art remains largely a mystery that motivates our study both of art making and art looking.

Despite the mysterious nature of art, people have always attempted to understand both the process and the product of art making. Often they are remarkably successful. They have communicated this understanding in several ways. Volumes have been written in the attempt to explain an art that has become accessible to a scholar as a consequence of deep and prolonged study. Others have expressed their understanding by practicing an art in an established style. This includes the special case of forgers who have demonstrated an understanding adequate to fool a skeptical audience.

In all these cases, however, the achievement of understanding an art form is communicated in such a way as to make it difficult for others to build upon the knowledge that has been acquired. Even in those cases where scholarly understanding is best communicated, it seldom can be used with the ease that ordinary scientific results can be used.

In defense of this limiting communication, it is often argued that art is inherently not communicable in the sense that scientific results are. We do not believe this. Our attempt here is to show that, at least in one aspect, an understanding of art can be communicated in just the way that scientific results are: it can be tested, validated, and used.

The aspect that concerns us is style (Schapiro 1953). When we are confronted with a homogeneous collection of art works, the first things that we observe are the formal properties: shape, color, arrangement,

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texture, size, orientation. And when we say that we can recognize a style, it is often these formal properties that we are recognizing even before we recognize the meaning (if indeed we ever do).

In the case of prehistoric art, we must forego any attempt to uncover meaning. But that does not preclude understanding the formal properties of the art work that lie at the base of its style. And such an analysis has often led to the classification of prehistoric works into stylistic categories. There are, of course, stylistic classifications based on non-formal properties like site location or co-occurrence of other artifacts. But we are concerned here only with stylistic classification based upon the content of the art work itself—its formal properties.

Diagrams of Art Works

An art work of consequence will often grab us with its multifarious aspects. A petroglyph will present a shape, a depth of engraving, a location, and a juxtaposition with others. A pictograph will also present hue, saturation, and intensity. But in reporting a finding, the archaeologist will often use a drawing to communicate the nature of the rock art. Everyone knows that this diagram fails to capture all these multifarious aspects. But it is significant to observe how much it does capture. Indeed, sometimes the diagram can capture aspects that are poorly rendered even with photographs. Many good examples of informative diagrams and the corresponding beautiful photographs are found in McCreery and Malotki (1994). So we are justified in studying diagrams of art works, knowing full well that much is necessarily left unsaid.

To render diagrams, we are fortunate to have available the mature technology of computer graphics. There is, of course, a technology that provides the ability to render computer images in full color with tonal variations much as in photographs. But there is no discipline for the manufacture of such images the way there is for the drawing of diagrams. Photographers will argue that the creation of photographs can be used to explain visual observations as well or even better than can the creation of drawings or diagrams. But the computer technology for creation of explanatory photographs is not nearly as mature as that for the creation of diagrams, as we will demonstrate.

So our attention here will be devoted to showing how one may create diagrams with the computer which serve to explain the formal properties of art works.

Who Does the Hard Work?

At the outset we must caution the reader that the tools which we describe here are only of use after much preliminary hard work has been done without the use of the computer. For the description of style in rock art, the computer makes very little contribution until after the archaeologist has achieved an understanding of the style to be studied. And at that point most of the hard work has been done by the archaeologist.

But the computer begins to justify its use when the scholar desires to test his or her understanding. Then follows a period of refinement of the style description which may justify the effort devoted to the use of the computer.

When the final result is achieved, the greatest benefit of using the computer appears in the form of algorithms that can be used by others to build upon the first style description to elaborate, correct, or improve it. We shall see how this works below.

Algorithms for Describing Pattern and Shape

The technology for computer processing of pictures and the creation of graphic images has existed for many years (Kirsch et al. 1957). Somewhat later (Kirsch 1964), we learned how to give explanatory power to the images that we could create with computers. This work led to development of shape grammars, widely used in architecture (Knight 1994). For rock art, shape grammars appear most useful for describing patterns. We have used shape grammars for describing painting style (Kirsch and Kirsch 1986, 1988a). Archaeologists have used shape grammars for describing rock art (Chippendale 1986), cave gravure (Muller 1986), and flint knapping (Hassan 1986).

Separately from the investigation of shape grammars has been the vast development of the technology of computer graphics. Annual meetings of the professional society, the Association for Computing Machinery Special Interest Group on

Graphics (ACM-SIGGRAPH) draw over 25,000 attendees. This technology appears most useful for the description of shape in rock art. It is also of use in archiving rock art image data (Kirsch and Kirsch 1988b), but that is beyond the purview of this paper.

We suggest that the description of rock art style can be thus divided into the description of shapes with computer graphic tools and, within these shapes, the description of patterns with shape grammars. As an example of such a partitioning of the description task we can consider Barrier Canyon style pictographs. Within each anthropomorphic figure best described with shape algorithms, we may consider the insertion of internal patterns with shape grammars.

Describing Patterns

We have used shape grammars for describing the patterns in the paintings of the American abstract painter Richard Diebenkorn (Kirsch and Kirsch 1986, 1988a). Figures 1a, b, and c show how such a grammar looks and Figure 2 traces the generation of a composition from the grammar. Implemented on a Sun workstation (Kirsch et al. 1988), the computer can produce an unlimited number of examples of Diebenkorn's style for use, *inter alia*, in debugging the grammar.

We can see that, *mutatis mutandis*, the patterns describable by this shape grammar are of the type that occur in some rock art (eg., the Barrier Canyon style pictographs.)

Describing Shape

Although the use of shape grammars is well established, there is little experience in using computer graphic shape algorithms for describing shape. We have been doing this for several years to describe the style of the Spanish painter Joan Miro. Incidentally, his painting style was indeed influenced by his familiarity with Spanish Cave art. And the paintings we have studied, his Constellation series, have the spirit of rock art insofar as they contain many shapes belonging to comparatively few shape classes, all arranged in complex compositions on a canvas.

It has been our intention to describe both the shape classes, which are relevant to rock art, and

the compositional arrangements, which are less relevant insofar as there is little evidence for such compositional arrangements in rock art (but see Chippendale [1986] for some contrary arguments.)

We have written programs in Macintosh Common Lisp to produce the Miro shape classes. These programs run interactively on an Apple Macintosh computer. The user can choose to generate any one of several shape classes. After choosing the shape class he is presented with a set of "sliders" with which he can vary any one of the parameters that characterize that shape class. As he varies the parameter of his choosing, he can see the effect upon the shape being generated.

A typical shape class in Miro's compositions is an anthropomorph shown in Figure 3. It has six parameters, each of which has 100 values. Thus there is a combination of 10^{12} different examples of this shape class which can be generated. In Figure 4 we see several of these 10^{12} examples generated at random from the shape class. It is noteworthy that although there is this immensely large class of shapes, the class is homogeneous as seen by visual inspection. Actually, the class is really too small because we can easily posit some variations that we might like to include that are not present in the six parameters and their combinations. We might like to allow the head of the anthropomorph to tilt, or the arms to bend downward. If those variations also had 100 allowable values, this would increase the size of the class to 10^{16} members. And the ease of programming in Lisp would allow us to include such modifications and many others.

Analysis and Synthesis

The goal of any description process is to achieve an understanding. But if that understanding is not further utilized, its accomplishment is hollow and unsatisfying. Thus if we can describe a collection of Rock Art with suitable pattern or shape algorithms, we would hope to utilize such a description to achieve analytical ability for newly encountered samples of Rock Art. But here we encounter a duality paradox.

The paradox is that those tools which are most powerful for description are a fortiori correspondingly less powerful as analytical devices. This

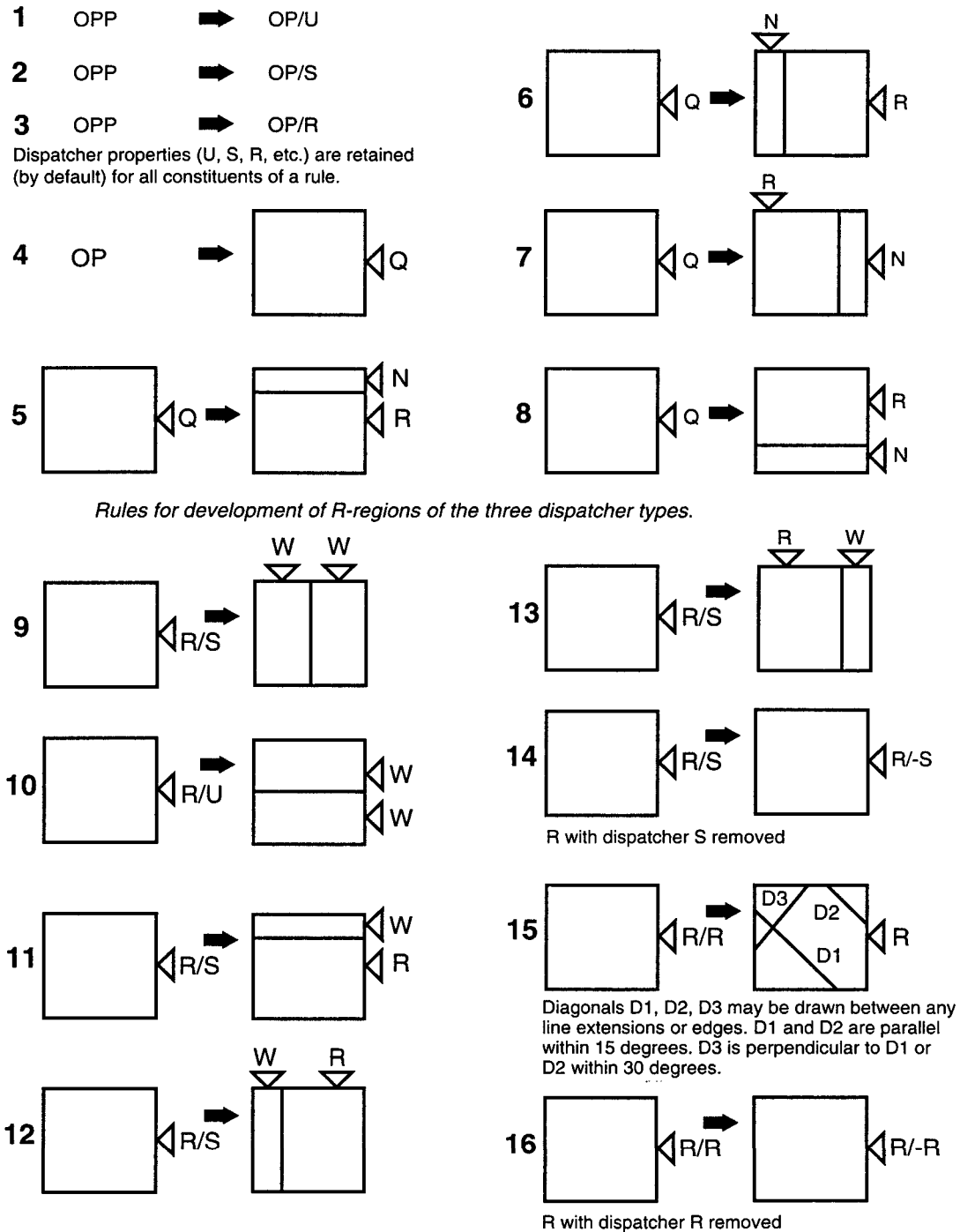
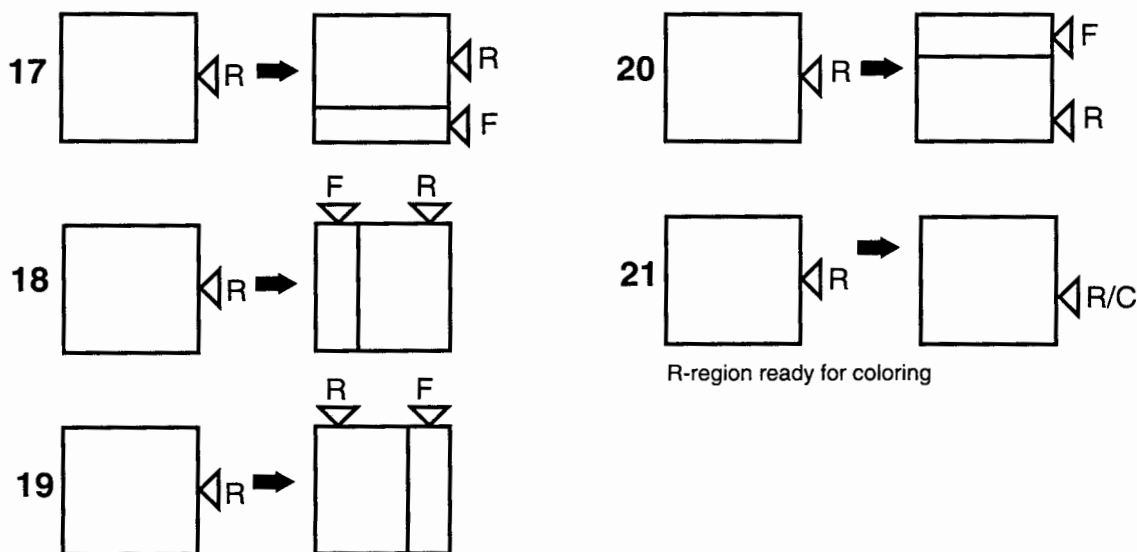


Figure 1a. A grammar for generation of painting patterns.

result is well known in Computer Science theory. Its application in the case of our interest is that of the two mechanisms we discuss, shape grammars and shape generation algorithms in Lisp, the former is descriptively weak and analytically strong whereas the latter is just the opposite.

With shape grammars we only can describe simple patterns (although we can produce infinite variety), but it is easy to use such a grammar to analyze samples previously unencountered in the construction of the grammar. The analysis produces a derivation of the new sample as if it were

Rules for development of R-regions of unlabeled type.



Rules for development of N-regions.

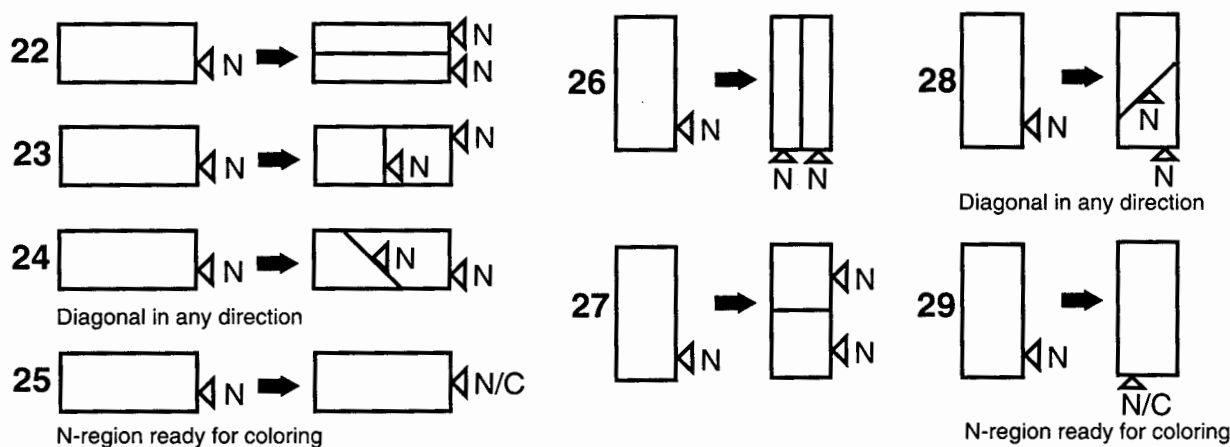


Figure 1b. A grammar for generation of painting patterns.

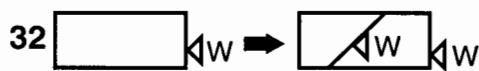
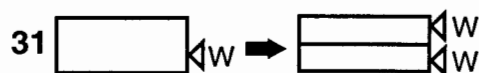
generated by the grammar. This analysis is thus a theory of how the new sample might have been produced. It is thus an explanation.

In the other case we have illustrated with the Miro anthropomorph example, we have used a very powerful programming language to generate the shapes. It is very clear to us that within this language we could generate any well understood class of shapes regardless of their complexity. But therein lies the rub! We have no a priori guarantee that the algorithms so constructed will lend themselves to analysis of new samples. In some fortuitous cases, such analysis may be possible, but not

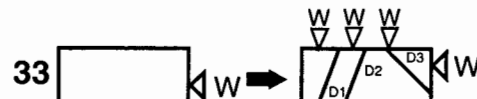
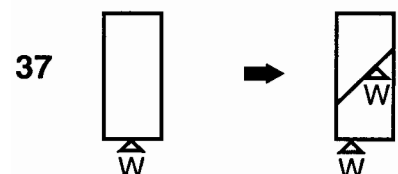
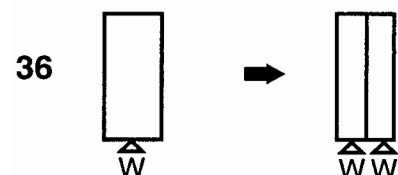
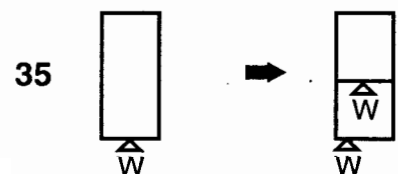
in general. We are thus left with the unsatisfying ability to demonstrate our understanding by generating the class of shapes under consideration, but we cannot use this understanding!

A resolution of this paradox is possible with the invention of algorithms of intermediate power. But this is still an area of research. Depending upon what kinds of patterns and shapes and arrangements are to be described, suitable intermediate level languages can be devised to enable some description (with moderate difficulty) and some analysis (with moderate ease). We leave these problems for future research.

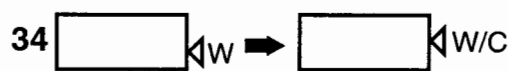
Rules for development of W-regions.



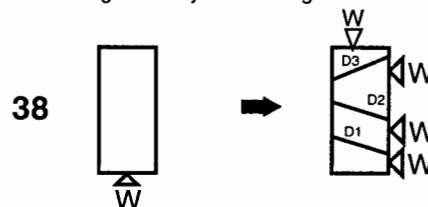
Diagonal may be drawn between any line extensions or edges.



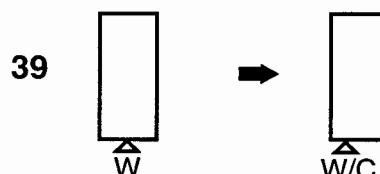
D1, D2, D3 may be drawn between any line extensions or edges. D1 and D2 are parallel within 15 degrees. D3 is perpendicular to D1 or D2 within 30 degrees.



W-region ready for coloring.

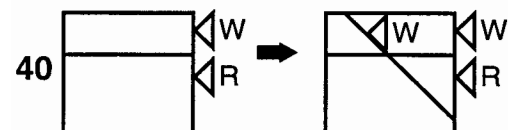


D1, D2, D3 may be drawn between any line extensions or edges. D1 and D2 are parallel within 15 degrees. D3 is perpendicular to D1 or D2 within 30 degrees.

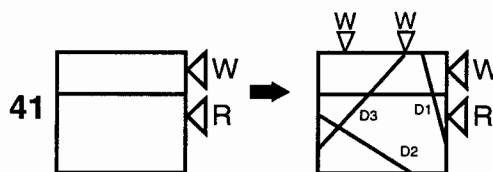


W-region ready for coloring.

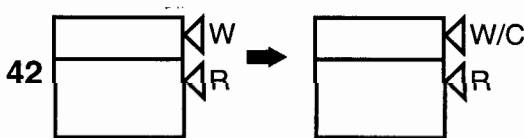
Rules for development of W and R-regions.



The diagonal may be drawn between any line extensions or edges. Note that the W-region is partitioned into two W-regions, whereas the R-region is not partitioned and remains a single rectangular region.



The diagonal may be drawn between any line extensions or edges. D1 and D2 are parallel within 15 deg. D3 is perpendicular to D1 or D2 within 30 deg. W is partitioned, but not R



W is ready for coloring. R may be further developed.

Figure 1c. A grammar for generation of painting patterns.

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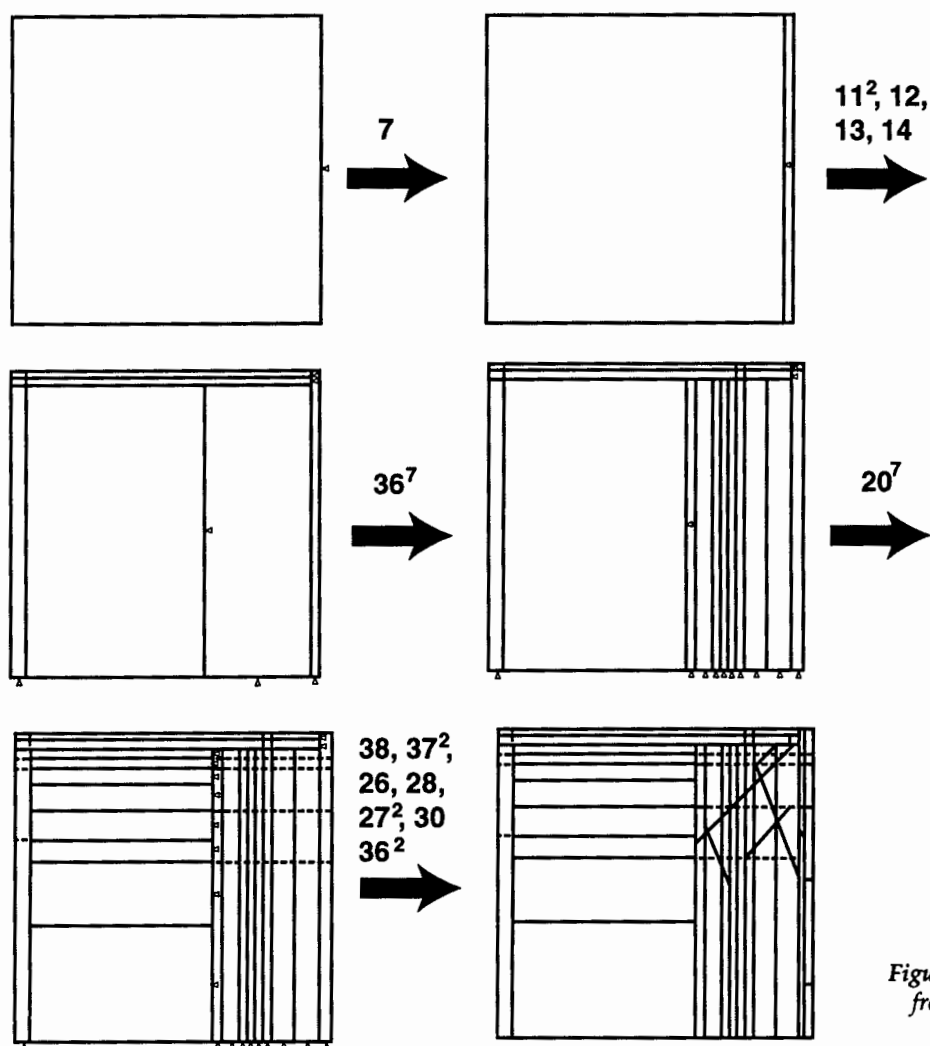


Figure 2. Generation of a composition from the grammar of Figure 1.

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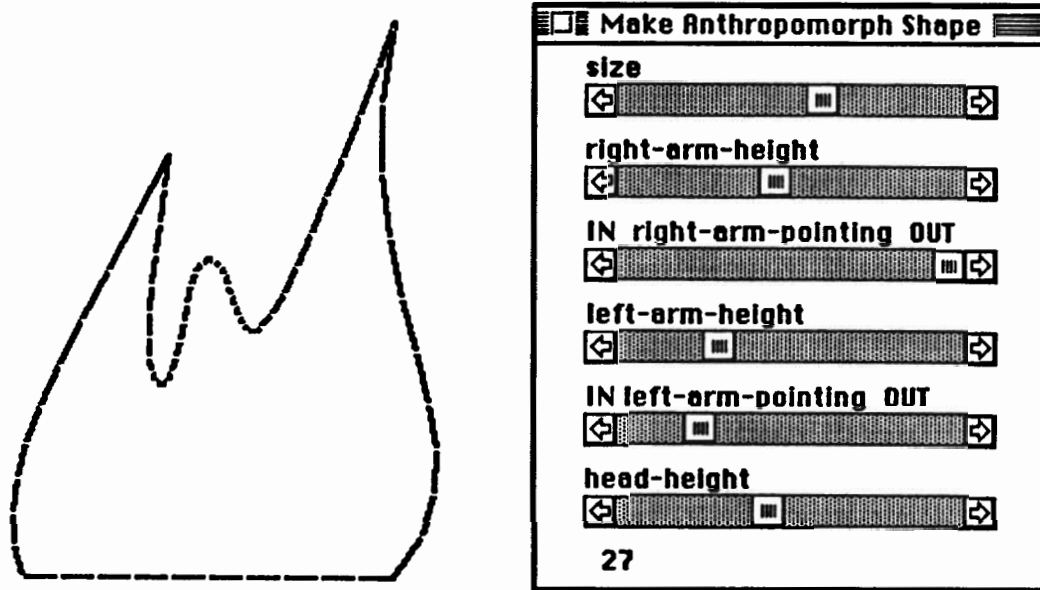


Figure 3. An anthropomorph with six parameters.

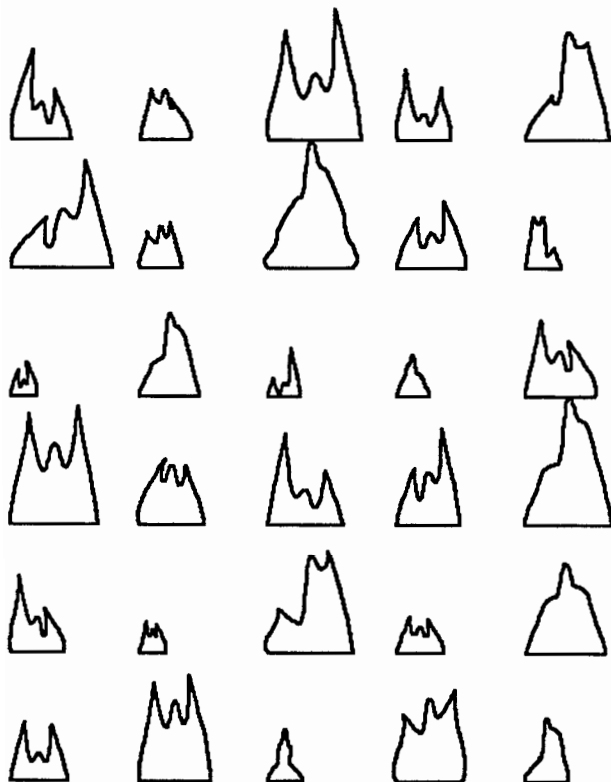


Figure 4. Generation of anthropomorphs with random parameters.

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