

A 4-PARAMETER MODEL OF VISUAL COMPLEXITY IN ABSTRACT IMAGES AND A COMPUTER PROGRAM FOR THE EMPIRICAL INVESTIGATION OF COMPLEXITY, PLEASINGNESS AND INTERESTINGNESS OF IMAGES BASED ON THE MODEL

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ABSTRACT

A 'new' 4-parameter model of visual complexity in abstract images was used to develop a computer program to both generate images based on the model and allow controlled 7-point Likert-scale judgments of generated images in terms of complexity, pleasingness and interestingness. The 4 parameters are the number of objects in the image and the number of possible colours, shapes and sizes that the randomly generated objects can possess. One part of the program allows independent setting of all the parameters and image generation, and then records generated images, as well as the user's judgments regarding the complexity, pleasingness and interestingness of the image. Another part of the program presents any set of previously generated images for judging in terms of these three characteristics.

Some preliminary findings using the program have established the extent to which subjective ratings of complexity, pleasingness and interestingness are reliable over time—an important issue, not frequently addressed, but potentially a very serious confound to research in this area. Also, early research with the program has established a correlation between the operational definition of complexity based on the model and subjective ratings of complexity: thus offering support for the validity of the model.

INTRODUCTION

The scientific study of the arts, like most scientific disciplines, has always been divided into two camps—the holistic and the reductionist, the macrocosmic and the microcosmic. In physics, this is represented by the conflict between relativity theory and quantum theory. Does the deepest understanding come from examining the cosmos or fiddling (at great expense) with elementary particles? In attempting to understand the arts from a scientific standpoint, we have those who would examine the cosmos, the actual art out there, and those who would ‘fiddle’ with what we believe to be the elementary particles of that art. Now, as an artist, I have the utmost respect for the whole, the true work of art, but I also see the potential value in an examination of the microcosm, the component parts. While the whole may well be greater than its parts, some understanding of the parts surely casts light on the whole.

One thing that has struck me about reductionist, empirical research on art and the aesthetic experience is the difficulty of determining (or defining) the elementary particles of any work of art and the response it evokes. Of course, this difficult process, taxonomy, is the first stage in any science. This isn’t to say that one does taxonomy and then is done with it, simply going on to investigate interactions and relationships, never looking back. Physicists started with electrons and protons and then neutrons, but continual revision of their taxonomy has led to what they call the elementary particle “zoo”. However, one does have to start somewhere, propose some fundamental particles that are logical—or at least commonsensical. Classification, pigeonholing, is the necessary, but of course not sufficient, foundation of all scientific disciplines.

A MODEL AND A TOOL BASED ON THE MODEL

In empirical aesthetics, there are two domains—the objective and the subjective; i.e., the artwork, and the art experience. What I have attempted to do is use modern computer methods to facilitate research into both—and their relationship to each other. I have written a computer program, which I call Dr. Miro, to conduct research on both, albeit (in the objective domain) only specifically for the two-dimensional visual image.

I took my inspiration for the objective (visual image) aspect from Vitz’s work on tone sequences (e.g., Vitz, 1966). Ruling out the confound of verbal information (i.e., music with lyrics), it is reasonable to say an abstract piece of music consists of a sequence of individual sounds: the atoms of the musical composition, as it were. And these atoms, individual tones, are defined by certain components—the pitch or frequency, the intensity or amplitude, and the duration. Of course, the musical elementary particle zoo lurks behind this simple taxonomy: there is the issue of ASDR (attack, sustain, decay, release), not to mention timbre or waveform. But if one holds constant the ASR of the ASDR and uses pure sine wave tones, one can build randomly generated and unadorned ‘tunes’ that can clearly be defined in terms of their elements.

Applying this model to a visual image leads to the following analysis. The visual analog of pitch (determined by frequency) is colour (also determined by frequency): a visual object has a colour. A visual object also has a shape and a size. That gives us three defining characteristics of a flat undifferentiated visual object, roughly analogous to a single auditory tone. An abstract *image* consists of a number of such objects. So a very simple, and commonsensical, 4-parameter model of an abstract image would have these characteristics.

Image 1: The 4-Parameter Model

- Each individual object's colour
- Each individual object's size
- Each individual object's shape
- Number of individual objects in the image

It is relatively easy to write a computer program that generates images by randomly selecting from a database of shapes, and randomly assigning a colour and size for each object added to the image. If one were to set arbitrarily finite limits to each of these parameters, (i.e., say how many objects in the image and how many possible shapes, colours and sizes these objects could have) and repeatedly, randomly sample within these limits, it would be possible to generate a virtually infinite number of images of any particular level of *objectively and clearly operationally defined* complexity—unconfounded by any associative or representational variables. This is, of course, very similar to what Vitz and others (e.g. Parham, 1973) did with tone sequences.

The program (which I call Dr. Miro) in its current version allows 12 settings for each of the 4 parameters. Determining what these settings should be involved a deeper analysis of the nature of colour, shape and size. (The number of objects is obviously objective—no pun intended.) It was essential that each setting for each parameter was at least intuitively as *equivalent* to all other settings for that parameter as possible, so that one could reasonably assume that complexity was only a function of *the number* of different objects in the set—not the nature (colour, size or shape) of the selected objects.

Colour was easy because it is clearly, objectively defined by three parameters—hue or frequency, intensity or brightness, and purity or saturation. Users of computer graphic programs are accustomed to manipulating these three variables to create the colours on their palettes. I decided to use the three additive primary colours (red, green, blue) and the three subtractive primary colours (cyan, magenta, yellow) at two levels of intensity (bright, dark). (I didn't want to include saturation, for somewhat the same reason that Vitz avoided its auditory analog, timbre.) This gave me twelve common colours that most people would call 'primary' and represented the conventional idea of the colour spectrum. Presumably no one of these colours would be generally considered more complex or interesting than another, and there is little that can be done to control the fact that judged pleasingness would be a matter of individual taste, but with definite statistical patterns (Granger, 1955).

Size was also easy, since it has a simple, objective relative relationship to the ‘canvas’ size. I simply chose 12 sizes for the objects that would vary by equal intervals from approximately 250 to 25,000 pixels in area. (The ‘canvas’ is 180,000 pixels in area.)

Shape was more problematic in terms of complexity. One method of operationally defining complexity of shape that has been used, and seems to match our intuitive definition, is the number of sides or vertices. (E.g., Day, 1967) To have complex shapes would thus confound matters. Furthermore, historically, certain shapes have been held to be inherently more pleasing; e.g., the circle is often called perfect, and squares are sometimes considered simpler and more pleasing than rectangles. While these problems cannot be completely resolved, I chose to use very simple shapes to offset, as far as possible, the biasing factor of number of sides or vertices. I settled on circles, ellipses, squares, rectangles, isosceles triangles, and equilateral triangles—in both solid and outline form.

[Image 2: Complete Database of Colours, Shapes, and Sizes Used](#)

The program generates random abstract images by manipulating the settings for these four parameters within the approved described limits. The images created are computer generated abstract art. Naturally, they are closer to the typical work of Klee or Miro than Pollock, because the objects are discrete, clearly defined objects, not amorphous.

[Image 3: Sample Dr. Miro Image](#)

An example should make the workings of the image generator clearer. Assume that the subject chose the following settings for the generation of an image.

- Colours = 6
- Shapes = 2
- Sizes = 2
- Number of Objects = 8

[Image 4: Sample Images Generated From Example Settings](#)

In preparation for generating an image according to these settings, the program randomly determines which possible colours, shapes and sizes are to be allowed for each component object. Say it selected the colours—bright red, dark green, dark blue, bright cyan, bright magenta, bright yellow. And assume it chose a solid circle and an outlined rectangle as the 2 possible shapes. Finally, say it picked level 8 and level 12 as the possible sizes.

The generated image would have 8 objects in it but they would all be either solid circles or outlined rectangles of size 8 or 12. And each object would be either bright red, dark green, dark blue, bright cyan, bright magenta, or bright yellow. However, it may very well happen through random sampling that, for example, only the four colours bright red,

bright yellow, bright magenta and bright cyan are used and that only one of the objects is of size 12.

Each time a new image is generated with these settings, the actual colours, shapes and sizes that are selected will most likely be different, but *the number of possibilities* for each parameter would remain the same. Another image generated according to these same settings might be selected from the colours bright red, dark red, bright green, dark green, bright magenta, dark magenta, dark yellow, and dark cyan; from the shapes solid rectangle and solid circle; and from the sizes 5 units and 8 units. And the image actually generated might only use four of the colours and only once use the solid circle as a shape for an object.

ABOUT THE PROGRAM

Since this program was intended as a research tool for investigating the relationship of objective characteristics of an image to subjective evaluations of the image, I had to decide on the evaluative properties. I chose, in accordance with traditional research such as that of Berlyne's and many others, the three common variables of interestingness, pleasingness, and complexity. What particularly interested me, and seemed potentially very useful, was unequivocally defining operationally an objective complexity that could be compared with subjective judgments of complexity.

[Image 5: Splash Screen](#)

The program has two modules—"Make Art" and "Judge Art". The introductory screen allows one to control a number of critical features of the program, including the extent of the delay after the image is generated or presented, which evaluations are requested, and whether evaluations are forced in the "Make Art" module.

In the "Make Art" module the user generates images by changing the settings for the four parameters. After each image is generated, the program can insist on an evaluation of the image on the three subjective ratings. Every image generated is stored in a simple ASCII data file so it can be recalled by the program and regenerated. Also stored in the file are any associated subjective evaluations.

[Image 6: Make Art Screen Shot 1](#)

[Image 7: Make Art Screen Shot 2](#)

[Image 8: Make Art Screen Shot 3](#)

In the "Judge Art" mode, the program reads in the selected image data files, and the user is asked to judge the images presented on the three characteristics of interestingness, pleasingness and complexity. These judgments are again stored in a data file associated with the image file. The judgment data files are also straight text (ASCII) files that can easily be imported into SPSS for analysis.

[Image 09: Judge Art Screen Shot 1](#)

[Image 10: Judge Art Screen Shot 2](#)

[Image 11: Judge Art Screen Shot 3](#)

SOME PRELIMINARY RESEARCH FINDINGS USING THE PROGRAM

I am presently analyzing the data from two studies using this program and hope to publish my findings in the near future. The amount of data generated and the variety of comparisons and relationships that can be investigated are staggering. Some of my early findings are so tantalizing, however, that I thought I might share them now, without going into any of the details of the studies.

1. RELIABILITY OF EVALUATIVE RATINGS

In this study the primary focus was on the reliability of subjective ratings (although a large number of secondary analyses are in progress). Many empirical studies rely on subject ratings of complexity, interestingness and pleasingness, but infrequently check the reliability of these ratings. When subjects are required to make ratings on things where they have no clear opinion or are not committed enough to form an opinion, the ratings they assign are just random, with a tendency to cluster in the middle of the rating scale, and so are essentially meaningless. As in all psychometric measurements, the retest reliability is extremely important if one is to draw any meaningful conclusions from subjective ratings.

The 96 subjects in this study used the Make Art module of the program to generate 50 images, rating each one on the three evaluative scales. One week later they were presented with the exact same images each had generated in the first session and again asked to rate them on the three scales. Given the number and abstract nature of the images, memory of previous ratings could effectively be ruled out as a confound, and so a simple correlation coefficient of reliability could be used as an indicator of how much credibility a researcher should attribute to quick, on-the-spot ratings of interestingness, pleasingness and complexity.

[Image 12: Retest-reliability Study Results](#)

Initial analysis of the data suggests some caution in trusting subject ratings. Here are the retest-correlations for subject judgments. While all were statistically significant, they are only what are usually called 'moderately strong' correlations.

- Complexity .68
- Pleasingness .60
- Interestingness .59

2: FACTORS DETERMINING COMPLEXITY RATINGS

Inspired by some further analysis of the results of the previous study, this study was an attempt to systematically determine how much each of the 4 objective parameters was contributing to the judged complexity. This study used a set of 72 pre-generated images systematically varied in objective complexity on the four objective parameters. Objective complexity for each of the parameters was defined as the range of settings that was sampled for each parameter in generating an image. 101 subjects participated.

[Image 13: Factors Affecting Judgments Of Complexity](#)

Initial analysis seems to indicate that (as data from the previous study hinted) number of objects has, by far, the best correlation with judged complexity and is the only one of the four statistically significant. This is, perhaps, not surprising, but the relative unimportance of the other parameters is. Further analysis to determine the comparative importance of the individual object's characteristics, with number of objects in the image held constant, should yield some interesting information.

- Each individual object's colour - 0.21 (n.s.)
- Each individual object's size + 0.23 (n.s.)
- Each individual object's shape + 0.23 (n.s.)
- Number of individual objects + 0.86 (p < .01)

CONCLUSIONS

1. Effective empirical investigation of aesthetic judgments of visual art from a reductionist perspective is most effective when based on a 'reasonable' taxonomy of the components of the art object. In two-dimensional, non-representational art, one such commonsensical taxonomy consists of four parameters: colour, size and shape of component objects—and the number of objects in the image.
2. A computer program such as Dr. Miro is a useful tool for investigating the relationships between the aforementioned objective parameters and the subjective aesthetic judgments, as well as for general investigation of the reliability of the subjective judgments so critical to research in empirical aesthetics.

NOTE

Copies of the current version of the Dr. Miro program can be downloaded for free from the following Web Site. Also available at this site are documentation for the program and a transcription of this presentation. <http://kenstange.com/drmiro/>

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