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THE AESTHETICS OF COMPOSITION: A STUDY OF MONDRIAN

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ABSTRACT

Subjects carried out a paired comparison experiment in which they were asked to make a preference judgement between a computer facsimile of an original Mondrian painting, and a modified version of the same picture in which the proportional relations of the compositional lines had been modified by a relatively small amount. Subjects were significantly better than chance expectations in their preference for the original Mondrians, suggesting that these paintings may encapsulate some universal principle of compositional order which can be detected by subjects.

INTRODUCTION

In principle, it is easy to paint a picture; as Gombrich put it, it is a matter of "framing and filling"—the delineation of a pictorial area followed by its filling with pigment [1]. A moment's consideration reveals however that there are many ways in which this can be done; and indeed if one considers that there are p pixels within a frame, each of which is drawn from a palette of c colors, then there are c^p possible pictures. One of the problems of painting is to choose a single one of those many possible pictures. Even after the image is constrained by the choice of subject matter, etc., this still leaves very many degrees of freedom which can be broadly summarized under the heading of the problem of *composition*. Does it matter if one particular arrangement rather than another is chosen? Artists are quite clear that not only does it matter, but that to a large extent it is such choices which form the central problem of the artistic endeavour.

If composition is a major problem to the artist, it is also the most difficult of the problems facing the experimental psychologist interested in the nature of aesthetics and the arts, principally because of the inherent problem of devising experimental stimuli that are aesthetically convincing and, at the same time, empirically tractable and manipulable. It is that problem which, in a tradition dating back to Fechner [2], has resulted in psychologists studying aesthetic preference for very simple stimuli such as rectangles and triangles (e.g., McManus [3]), or colors (e.g., McManus et al. [4]). However, because of their very nature these stimuli cannot be used to study composition, which is essentially concerned with the arrangement and the inter-relation of elements, rather than with the elements themselves. Some studies have brushed the fringes of the problem, although few have attacked it frontally. McManus et al. looked at the effects upon the "balance" of a picture of removing portions from it [5], and McManus asked subjects to make preference judgements for very simple compositions in which a single object (a boat or a church) was placed at different positions within a frame [6]. Finally the concept of "compositional geometry" has been investigated by McManus and Kitson by randomly placing dots within a frame, under certain geometrical constraints [7]. However, none of these studies have met the major challenge of studying composition by manipulating stimuli derived from genuine works of art which are generally accepted as of real aesthetic significance. Ultimately the aesthetics of the rectangle will tell us as little about the visual beauty of a Raphael as the physics of the violin will tell us about the musical beauty of Bach's Brandenburg Concertoes.

The advent of cheap, powerful microcomputers with adequate graphic display facilities now means that certain types of visual images can be manipulated easily (although still we are a very long way from being able to rearrange the components of a Raphael *Madonna* and still retain an aesthetically convincing object). The style of Dutch artist Piet Mondrian (1872-1944) evolved throughout his life, from an expressionistic realism through to a severe, austere abstraction in which the paintings of his mature, classical style consist only of black vertical and horizontal lines placed on a white background, and with some of the rectangular areas filled in with primary colours (see Mondrian [8]). Such pictures are sufficiently simple in geometric terms to be reproduced straightforwardly on a computer screen, and are sufficiently well-defined to mean that the elements of which they are composed, the black lines, can be moved by small amounts without destroying the essential structure or syntax of the picture. Once this technical facility is available, then an important question arises for aesthetics: to what extent are the placings of the elements of a Mondrian painting merely arbitrary, and how much can they be seen as the optimization of a compositional problem (as has been suggested by Hill [9]), with their particular placing being seen as aesthetically more successful than any of a range of similar but different placings? That

Mondrian himself saw these compositions as indeed optimal is suggested by the lengthy period during which the pictures were kept in his studio, to be worked on, studied and revised, and by the existence of a small number of unfinished pictures in which it is clear that lines are being moved by small distances by the use of over-painting (e.g., Henkels [10, pp. 63, 64, and 69]).

In this article we report a study in which subjects were shown pairs of computer-generated stimuli, one of which reproduces the exact composition of a Mondrian painting from his classical, mature period, and the other of which is a "pseudo-Mondrian" with a similar structure but with the elements randomly perturbed to alter the proportional relationships.

METHOD

Stimuli

Twenty-five paintings by Mondrian were used for the study. They were chosen as being those from the mature period in which the background was a pure white (without any areas of pale grey), in which all the black vertical and horizontal lines extended either completely to the frame, or to another black line, and in which the solid areas of color between the lines were primary colors (red, blue or yellow). These constraints meant that the position of each line could be defined entirely as a proportional distance between two other lines or edges. The proportions were measured from photocopied photographic reproductions of the paintings.

The position of each line in the composition can be expressed as a proportional distance between two other lines (and hence takes a value between zero and one). Each line can then be perturbed within the composition by altering its proportional relationship to the lines around it, so that some other proportion in the range zero to one is chosen. For such a technique to be successful in altering the proportional relationships without changing the fundamental syntax of a picture it is necessary that lines do not move outside the bounds set for them by other lines, and that therefore the proportions are hierarchically nested within one another. As an example, consider Figure 1. The measurement commences (arbitrarily) in the top left-hand corner, and moves generally downwards and rightwards. The position of line b is expressed as the proportional distance between the two edges, a and d. Line c is then expressed in relation to lines b and d. The result is that whatever values these two proportions then take, line c must always be to the right of line b. Line f is measured relative to e and k, and line g is relative to f and k. Likewise line h is relative to g and k, line i relative to h and k, and line j relative to i and k. If the proportional placings of the lines are changed then the topological inter-relationships of the lines stay similar; it is as if the picture were drawn on an infinitely stretchable rubber sheet.

For each of the twenty-five Mondrian paintings (M), two pseudo-Mondrians were produced (P1 and P2). P1 was produced by taking each proportional spacing

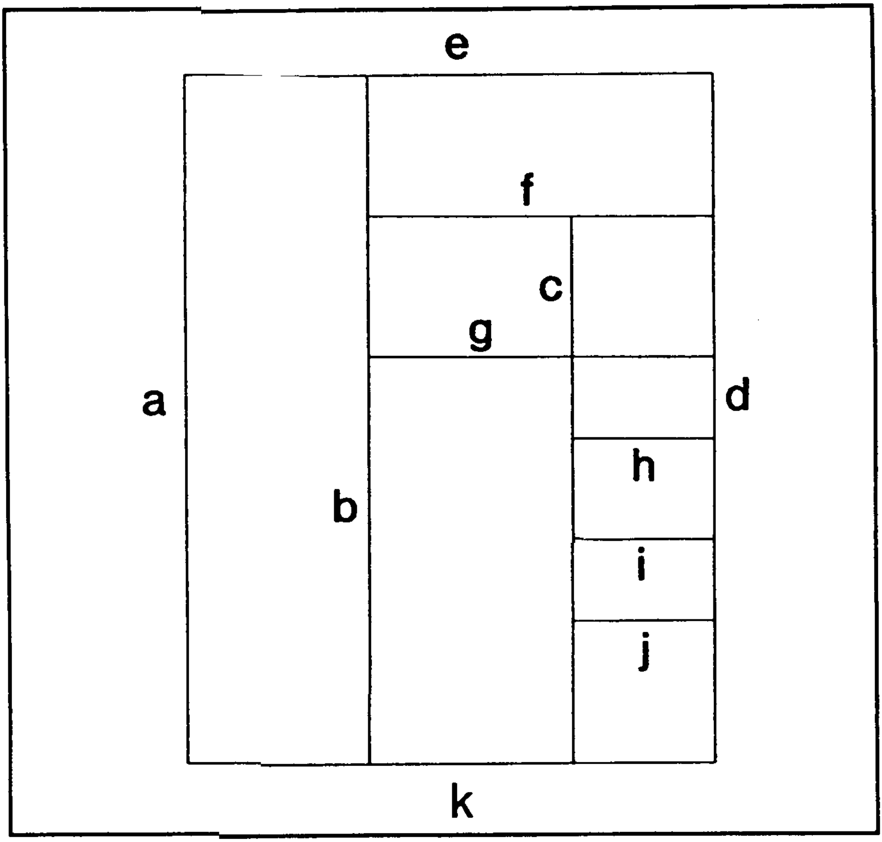

Figure 1. The method by which a Mondrian painting was encoded.
See text for details.

in M, transforming it by a logistic transformation (logit(x) = log(x/(1 - x))), randomly adding or subtracting a value of 0.5, and then back transforming the value through the reverse transformation (x = exp(x)/(1 + exp(x))) to produce a proportion which is necessarily constrained to be in the range 0 to 1. The advantage of the logistic transformation is that proportions at the middle of the range and at the extremes are altered by proportionately similar amounts. The P2 pseudo-Mondrian was produced by a similar process except that a value of 1.0 (rather than 0.5) was added to the logit, producing an image which is twice as deviant from the original as was the P1 image. The random choice of addition or subtraction for each parameter in the P1 image was independent of the random choice for that parameter in the P2 image.

Stimuli were generated by an IBM PC/AT computer using EGA graphics, and were projected directly onto 35mm Ektachrome film using a Polaroid Slidemaker, thereby producing a high quality image without any obviously visible raster scan.

Design

Each subject saw a series of seventy-five pairs of stimuli, consisting of the pairs M *vs* P1, M *vs* P2 and P1 *vs* P2 for each of the twenty-five original paintings. The order of the pairs was randomized, and M, P1 and P2 each occurred equally often on right and left.

Subjects were told that they would be seeing pairs of pictures in which one of the pictures would probably be an actual Mondrian and they were asked to indicate which they preferred by marking a cross on a six-point scale, from "much prefer left-hand image," through "prefer" and "slightly prefer" left-hand image, to "slightly prefer," "prefer," and "much prefer" right-hand image.

Subjects

Fifty-two subjects took part in the experiment. Thirty-two subjects (17 male, 15 female) were Foundation Arts students at Middlesex Polytechnic, and twenty (7 male, 13 female) were psychology students at University College London. Subjects were tested in groups of varying numbers, with the stimuli being projected in a darkened room by means of a slide projector. Prior to the experiment proper the subjects were given a series of five practice stimuli to acquaint them with the range of stimuli and responses.

RESULTS

Although subjects had made their responses on a six-point rating scale, these results were collapsed to a two-point scale indicating whether or not the subject had preferred the original Mondrian (M) to either of the pseudo-Mondrians (P1, P2) (and in the case of P1 *vs* P2 pairs, whether the subject had preferred P1, the more Mondrian-like of the two stimuli).

Of 3891 judgements, 2106 (54.1%) were "correct" (choosing M in M *vs* P1 and M *vs* P2 pairs, or P1 in P1 *vs* P2 pairs). Subjects were correct in an average of 40.50 cases out of seventy-five (*SD* - 8.14), which is significantly higher than the chance expectation of 37.5 ($t = 2.63, p < .01$). Figure 2 shows the distribution of scores attained by individual subjects in comparison with that expected under a binomial distribution with chance probability of making a correct judgement. The open area in the expected distribution indicates where 95 percent of the population should fall, and the solid areas represent the remaining 5 percent of the total area, split to left and right of the mean. The solid areas in the observed distribution are based on those in the expected distribution, being those subjects outside of the 95 percent confidence interval for the binomial distribution. Three out of fifty-two

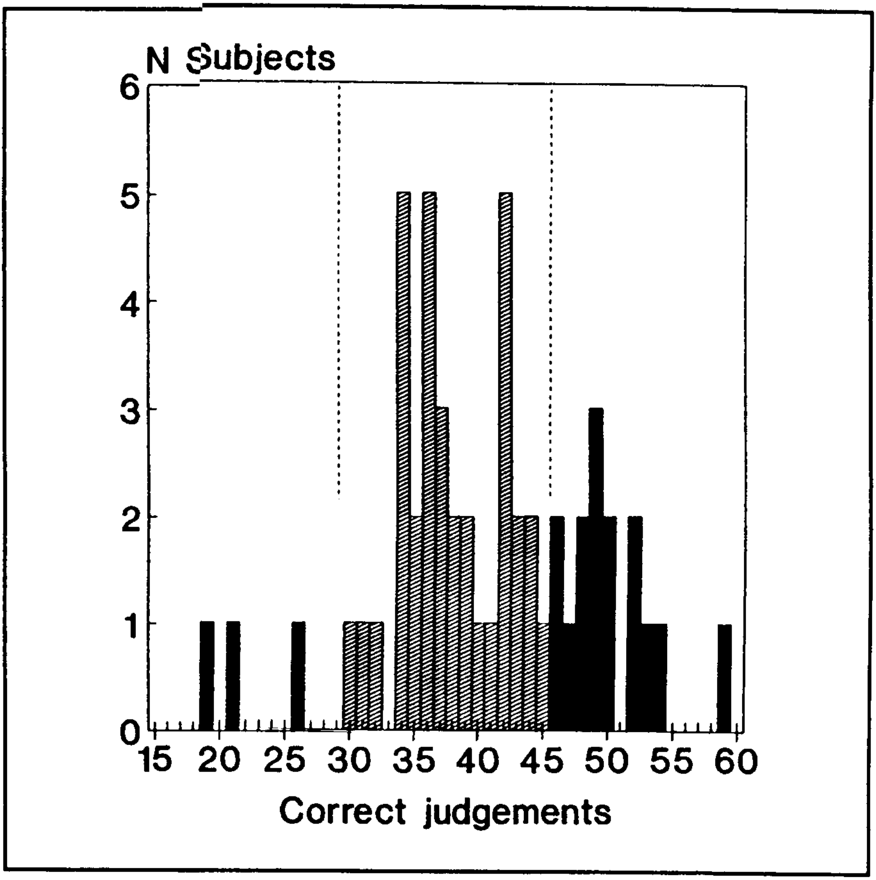

Figure 2. Number of correct judgements made by each of the subjects. The binomial distribution was used to calculate the significance of individual subjects, those shaded in dark being significantly different from the chance expectations at the 5 percent level of significance.

(5.8%) subjects are significantly below the 95 percent range (compared with an expected figure of 2.5%) whereas fifteen out of fifty-two ((28.8%) are significantly above the 95 percent range (compared with an expected figure of 2.5%). Taken overall, therefore, these results suggest that some subjects are indeed capable of distinguishing the original Mondrians from the pseudo-Mondrians.

Analysis by pictures, Figure 3, finds a similar result: Each picture is judged three times by fifty-two subjects, making a total of 156 judgements, and hence a chance expectation of seventy-eight correct responses. Two out of twenty-five (8.0%) of pictures were judged correctly on less than sixty-six occasions (as compared with an expected value of 2.5%), and eight out of twenty-five (32.0%)

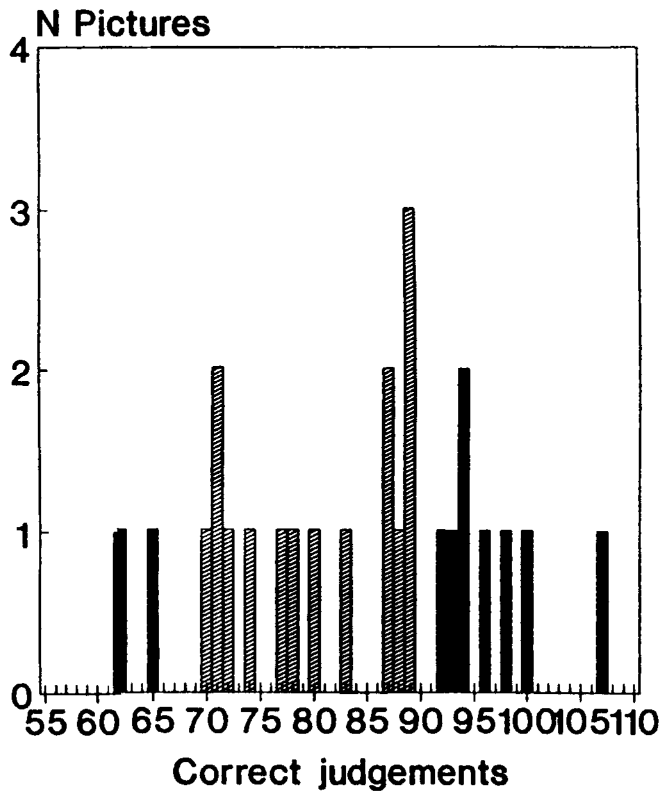

Figure 3. Number of correct judgements made by each of the pictures. The binomial distribution was used to calculate the significance of individual pictures, those shaded in dark being significantly different from the chance expectations at the 5 percent level of significance.

were judged correctly on more than ninety occasions (compared with an expected value of 2.5%). These results suggest therefore that there are particular Mondrians which can be distinguished reliably from pseudo-Mondrians.

Comparison of M *vs* P1, M *vs* P2, and P1 *vs* P2 pairs found that subjects were equally likely to be correct with M *vs* P1 pairs (722/1293 = 55.8%) and with M *vs* P2 pairs (712/1298 = 54.9%) but were less likely to be correct with P1 *vs* P2 pairs (672/1300 = 51.7%). Taken overall the psychology students were more likely to be correct (861/1495 = 57.6%) than the Foundation Arts students (1245/2396 = 52.0%).

Figures 4 and 5 show monochrome reproductions of two pairs of images, as seen by the subjects. Figure 4 shows an original Mondrian to the left and a pseudo-Mondrian (P1) to the right; 71 percent of fifty-two subjects preferred the original Mondrian. Figure 5 shows an original Mondrian to the right and a pseudo-Mondrian (P2) to the left; 73 percent of fifty-two subjects preferred the original Mondrian.

A repeated measures of analysis of variance of the number of preferences for the original Mondrian out of a total of twenty-five, with the three types of stimulus pairs as within subject measures (M *vs* P1, M *vs* P2 and P1 *vs* P2) and with type of subject (art student versus psychology student) as a between subjects measure, found an almost significant difference between the stimulus types, $F(2,100) = 2.78, p < .10$). *A priori* comparisons showed that there was a significantly better performance for M *vs* P1 and M *vs* P2 pairs than for P1 *vs* P2 pairs, $F(1,100) = 5.37, p < .05$), but no significant difference between M *vs* P1 and M *vs* P2 pairs, $F(1,100) = 0.20$, *NS*. There was an almost significant difference in overall performance between art students and psychology students, $F(1,50) = 3.34, p < .10$, but no evidence of an interaction between subject type and stimulus type, $F(2,100) = 0.41$, *NS*.

Analysis of the correlations between the performance of individual subjects on the three types of stimulus pairs, showed that high performance on one type was significantly correlated with high performance on the other types (M *vs* P1 with M *vs* P2: $r = .54, n = 52, p < .001$; M *vs* P1 with P1 *vs* P2: $r = .41, p < .005$; M *vs* P2 with P1 *vs* P2: $r = .69, p < .001$). Similar correlations were found for both art students and psychology students (e.g., M *vs* P1 with M *vs* P2: art students $r = .59$, psychology students, $r = .37$).

DISCUSSION

Only two previous studies of which we are aware have looked at the work of Mondrian and used his pictures as the basis for a formal experimental analysis. The study of Noll [11] compared Mondrian's *Composition with Lines* of 1917 with a computer-generated version of the same. Subjects were found to prefer the computer-generated version of the image to the real thing. However few valid inferences can be drawn from that study as it is obvious on examination of the synthetic version of the picture that it differed from the original not only in its compositional form but also in many simpler, first-order statistics, such as the shapes of the pictorial elements, and their size distribution. The other study in which synthetic Mondrians have been created is that of William Vaughan, who created quasi-Mondrians on a BBC computer; in a newspaper interview (see Fisher [12]), he said "I invited people to judge whether they were seeing a simulation of an actual Mondrian or not. . . . The demonstration that real Mondrians are far more than random configurations is in itself an important one."

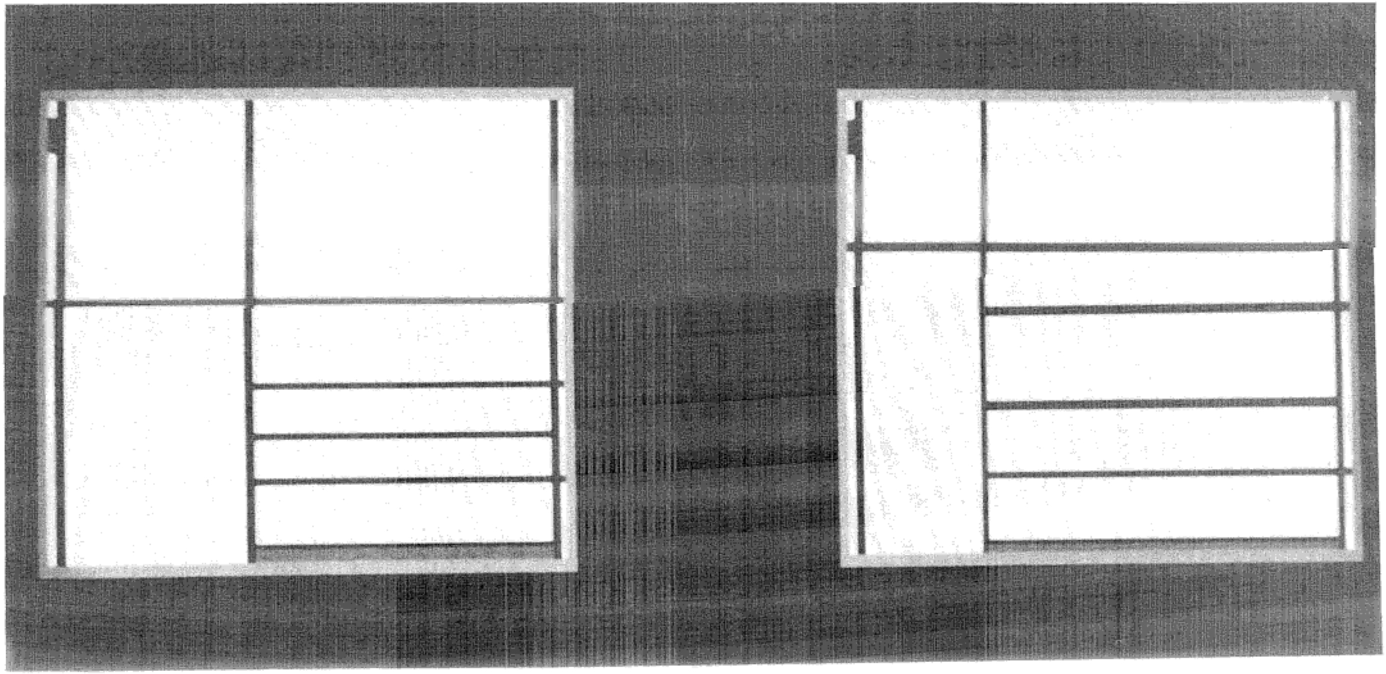

Figure 4. Based on Mondrian's "Composition with Red and Black" (1936), Museum of Modern Art, New York. thirty-seven of the fifty-two (71%) subjects preferred the original (M) on the left, compared with P1 on the right.

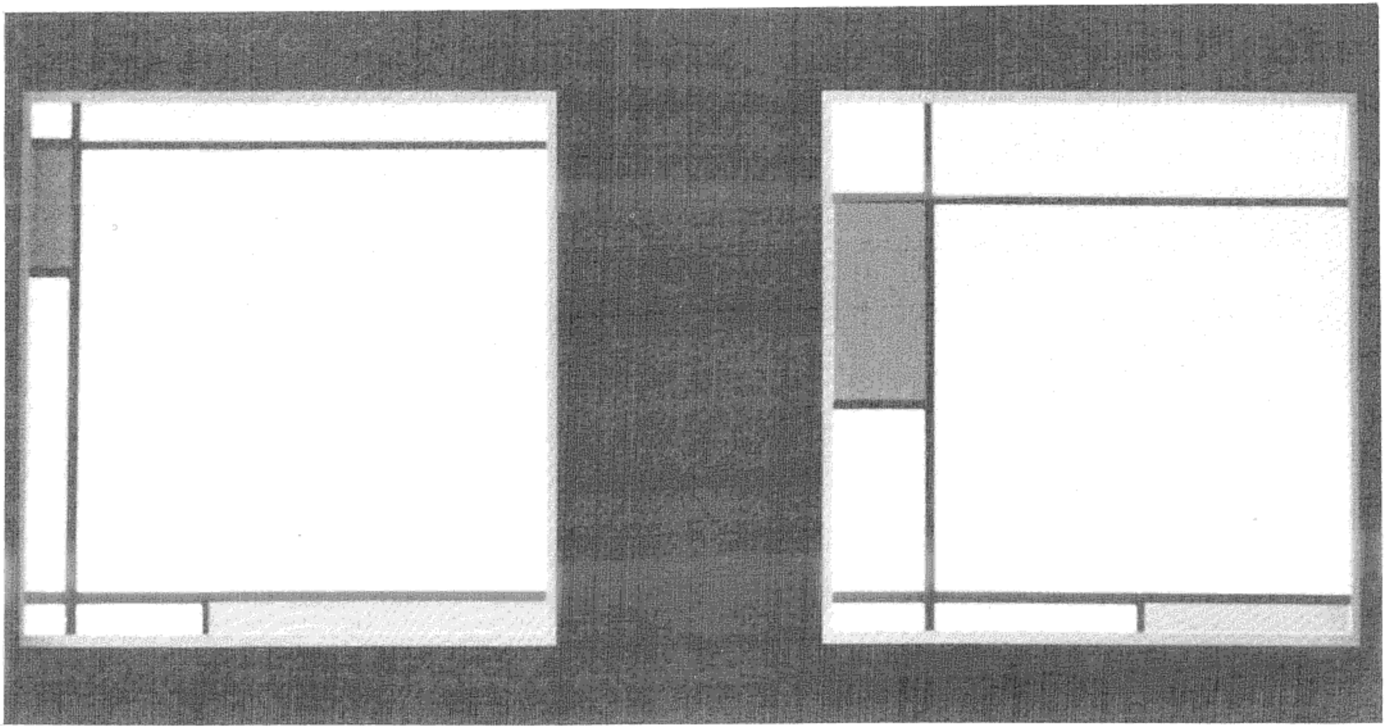

Figure 5. Based on Mondrian's "Composition with Red, Yellow and Blue" (1927), from the Collection of Mr. and Mrs. James W. Alsdorf, Winnetka, Illinois; exhibited at the Guggenheim Museum, New York, 1972. thirty-eight of the fifty-two (73%) subjects preferred the original (M) on the right, compared with P2 on the left.

No further details were given, although the computer program for generating the stimuli has been published Vaughan [13].

This current study has taken a large number of Mondrians, modified to only a moderate degree, so that the original structure is retained, and shown that ordinary subjects can reliably distinguish the originals from the pseudo-Mondrians. There are also suggestions in the data that some subjects are rather better at the task than others, and that some pictures are easier than others. Additionally, although Mondrians can be distinguished from pseudo-Mondrians, one pseudo-Mondrian cannot reliably be distinguished from another pseudo-Mondrian. Taken together these are important results for experimental aesthetics since, if they can be replicated, the method will provide an empirical technique which will allow analysis of the nature of composition; real works of art, judged by most critics to be of the highest aesthetic order, can be manipulated under controlled experimental conditions to discover the formal principles underlying them. From the point of view of understanding the art of Mondrian, the result supports what most sensitive viewers of his paintings have long known: that the pictures are not random configurations of lines, but instead are optimal aesthetic configurations (or are at least better than similar and related configurations).

The question remains as to the precise form of information that the subjects are deriving from the images in order to carry out the task. Several possibilities arise. Subjects may be observing some simple first-order statistic in the images, such as the mean height-width ratio of the rectangles composing the image, and choosing the image which is closest to their overall preference for rectangles; and since there are population preferences for rectangles that may result in an aggregate correct detection of the original Mondrians [3]. A variant of the hypothesis would suggest that subjects are detecting some other distributional parameter derived from rectangle shapes, or whatever, perhaps involving the variance, range or spread of the different components in the overall image. An alternative type of hypothesis would consider the second-order statistics involving not only the basic elements of the image but their higher-order inter-relations. Boselie has shown that with simple geometric figures, subjects prefer those which not only show simple proportional relationships but also have higher, or "complex," relationships [14]. A Mondrian image is rich in such potential proportionality, which may therefore be detected by subjects. Such hypotheses are in principle testable by measurement of the original and transformed images, and comparing them on a range of metrics.

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