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COMPOSITIONAL GEOMETRY IN PICTURES

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ABSTRACT

The aesthetic effect of pictures has been suggested to depend in part upon the existence of an implicit or explicit geometrical basis to their composition. In Experiment 1, subjects identified the significant points which might form the basis for such a geometry. In Experiment 2, a different group of subjects expressed preferences either for intact or cut versions of the pictures used in Experiment 1, and for sets of dots based upon the significant points within those cut and uncut pictures. Although subjects showed an overall preference for uncut rather than cut stimuli (in which it was presumed that cutting would have destroyed much of the compositional geometry), both for pictures and for dot stimuli, there was no correlation between the judgments of pictures and dot patterns, either between picture or between subjects, suggesting that compositional geometry was not of aesthetic significance in preference judgments. That conclusion was reinforced by Experiment 3, in which subjects showed no evidence of a preference for synthetic stimuli which were produced so that they had significant geometrical structure.

> To the eye there is displayed a confused and inarticulate juxtaposition of things; and to put this into order is the task of the human spirit
>
> [Friedländer, 1, p. 91]

The harmonious placing of the multifarious elements of a painting upon canvas (what Gombrich [2], called *framing* and *filling*) is perhaps the central process that distinguishes great art from indifferent art, and which possibly confers some of the timeless quality which allows a painting to transcend any purely local limitation of its interest to a particular time, place, or culture. In addition such purely aesthetic properties achieve additional emphasis in abstract rather than representational painting, and allow greater insight into the difference between good and bad examples of such art. Carpenter and Graham, for instance, state that:

> When we say that a work of art has 'visual form' we mean a certain order of relationships and equilibrium between the parts, that is both expressive and visually right. There is a kind of inevitability which suggests that out of the unlimited possibilities the artist has found one correct way of expression his version [3].

The underlying basis of this sense of "visual rightness" is unclear, although it is generally accepted that it must in part be the consequence of the integration or inter-relation of a number of elements with the pictorial frame. As Valentine [4] put it, "the picture is offered as a unity and must be apprehended as such," a view which may also be found in Ruskin [see 5, p. 261], and which has also been argued in the context of pictorial balance by McManus et al. [6].

A theory which has achieved support both within the psychological literature [7, 8], as well as from some art historians [9, 10] is that a satisfying composition is one in which there are simple geometric relations among the significant elements of the picture. The idea dates back primarily to Vitruvius, and prior to that to Pythagoras, and was extensively used in architectural composition during the renaissance [11]. In particular, there has been an extensive literature suggesting the golden section as the basis for such geometry [12]. Both Thomas [9] and Bouleau [10] give large numbers of examples in which attempts are made to demonstrate that the most important features of paintings are placed in relation to simple underlying geometric divisions of the picture frame. Perhaps the most generally well-known example of such geometric device is the isosceles triangle which seems to surround the figures in such pictures as Raphael's Madonnas [1, p. 92; 10, p. 122; 13]. It is undoubted that in *some* cases artists and art students do indeed use such devices for laying out works. The critic Konrad Lange said in 1907 that "artists now wallow in canonic proportions, the golden section, the equilateral triangle" [5, p. 238]. Nevertheless, specific examples of such usage are rare, and Bouleau [10, pp. 125-128] puts great emphasis on ten preparatory sketches by Claude Lorrain in which such compositional lines are indeed visible (although it could also be argued that they were merely used for "squaring up" from drawing to canvas). Two problems exist for such a hypothesis, of a "secret geometry" underlying good composition. Firstly, in many cases there are reasons for doubting that even apparently good examples of such geometrical composition are statistically convincing; Thomas for instance uses lines, triangles and arcs of circles based upon mid-points, quarters, thirds, fifths, golden sections and square-root divisions of sides [9]. The definition of a significant point or form within the body of a painting is not always obvious or beyond reasonable dispute, and is certainly not always precise. There thus seems to be a real risk that with a sufficiently large number of possible construction lines then there must always be at least some which pass within a specified tolerance limit of a so-called significant point. The statistical problem is similar to that encountered in the interpretation of megalithic monuments in relation to significant astronomical features [e.g., 14, 15] or in the search for "ley-lines" within the landscape [16], neither phenomenon still having been convincingly demonstrated to occur beyond the expectations of mere chance. Secondly, and far more importantly from the point of view of psychological explanations, is whether any such underlying geometry is responsible for the *aesthetic* sense of good composition. Geometric construction is neither necessary nor sufficient for structural stability in architecture; the question is whether it is necessary for success in aesthetic construction.

In the present article we consider how well subjects can locate significant points within a painting, we examine the siting of those points, and we ask whether the geometric inter-relations of those points might be used to explain subjects' preferences for paintings.

The rationale for the present experiments relies on two assumptions. First, if we remove a portion from the top, bottom, or side of a painting, then this will necessarily disrupt many global geometric properties of the composition. For instance, a point which was exactly at the intersection of the diagonals would no longer be so after removal of a portion. Second, if the aesthetic qualities of the composition arise because of the formal geometry implicit in the relationship of the significant points, then that geometry should also be apparent when stimuli are presented which consist only of the significant points arranged as black dots on a white background. In addition, as before, removal of a portion from side, top or bottom of such an artificial stimulus should disrupt the geometric relationships, and should result in an aesthetically less pleasing stimulus.

EXPERIMENT 1

The purpose of Experiment 1 was to determine whether subjects are capable of judgments of the location of important or significant points with paintings, and to obtain estimates of these points for use as stimuli in subsequent experiments.

Method

Ten subjects (4 male, 6 female) from a range of backgrounds and ages took part. All had expressed an interest in the visual arts. Each subject was presented with a series of forty-eight colored post-card reproductions of paintings from the National, Tate, and Courtauld Institute Galleries in London and was asked to indicate, on a monochrome photocopy of each picture, where the important points were located. The paintings used are listed in the Appendix. The precise instructions given were:

> In this experiment I am going to present you with a series of reproductions of some works of art, one at a time. For each picture I would like you to decide which are the most important points in the composition of that picture.

> The important points are those parts of the pictures where your eye seems to be drawn immediately, and which determines the pictorial composition. Pictures can have different numbers of such points, according to their subject matter, and different observers might well differ in their judgement of what and how many those important points are.
>
> What I would like you to do is look for a minute or so at the reproduction of a picture, and then indicate by drawing a cross on the photocopy where you think the *most* important point is; then write a number 1 alongside it.
>
> Then mark a second point, with another cross, and write a 2 alongside it, continuing until you feel that you have marked the important points in the picture.
>
> The precise number of points that you mark is entirely up to you, and will depend on the particular picture, but as a very rough guide please mark at least 4 points on each picture, with a maximum of perhaps 12 points on each picture.
>
> If you are not entirely sure where to place a point, but know in which area of the picture it should lie, then simply mark the centre of that area.
>
> There is no limit on the time you can take to carry out the task but in general it is your immediate rather than your deeply considered opinions which are of interest.
>
> There is a total of 48 pictures to be judged, so please do not take too long on each one, or the experiment will be very time-consuming.

In addition to these instructions the subjects were also given reproductions of Figure 15b from Thomas [9], to illustrate the importance of points in helping a composition, and Figures 113 and 120 from Yarbus' [17] study of eye-movements to illustrate the areas where the eye rests longest during examination of an image.

Results

The ten subjects each marked an average of 5.2 points on a picture ($SD = 2.7$; range 1.3-7.4), and the forty-eight pictures were each marked with an average of 51.7 points ($SD = 5.9$; range = 40-67). Subjects reported no difficulty in making such judgments. No formal statistical analysis was carried out, although informal comparisons did suggest that subjects showed considerable agreement in the placement of points, of which Figures 1a and 1b are examples, showing the locations of all the judgments of all subjects.

If the hypotheses of Thomas and Bouleau are correct, that geometric construction plays a major role in the construction of a picture, then a weak prediction is that, averaged across pictures, certain positions should be relatively more likely than others—for instance at the intersection of diagonals, or on positions around equilateral triangles formed from the base. In particular it should be relatively less common for points to be p laced at the periphery than the center, since these points

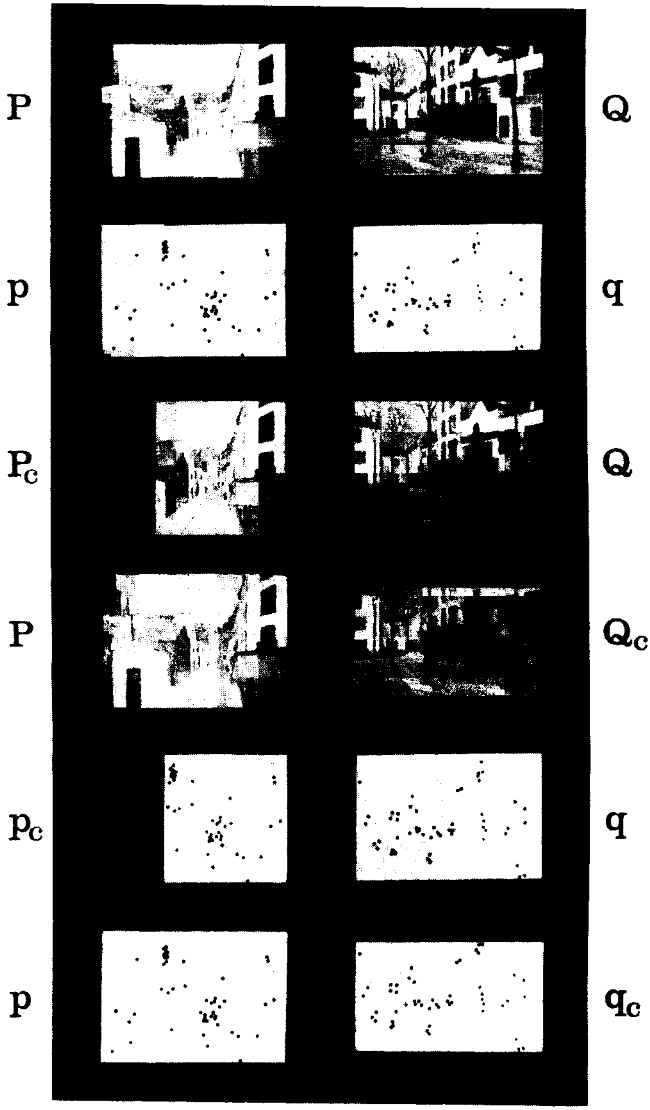

Figure 1. Shows examples of the stimuli used in Experiments 1 and 2. P and Q are stimuli 11a and 11b, and p and q represent the dot versions produced by subjects in Experiment 1. In Experiment 2 subjects saw either P chopped (Pc) and Q intact, or vice-versa (P and Qc) (rows 3 and 4 respectively) and saw p chopped (pc) and q intact or vice-versa (p and qc) (rows 5 and 6 respectively).

are less likely to relate to intersections of significant geometric features. Figure 2 shows a scattergram of all the judgments of all the subjects on all the pictures, different height-width rations of pictures being scaled so that points are all lying within a square. It can be seen that the points are not homogenous over the picture space, there being a tendency for points near the periphery to be less common, and there being some excess of points near the central vertical line and within an approximately equilateral triangle formed from the base. The anisotropy becomes more visually apparent if the figure is turned upon its side or upside down. A more formal analysis was produced by dividing the area into sixty-four equal sized squares and counting the number of points within each. The top half of the area contained 1139 (45.9%) dots as compared with 1343 (54.1%) in the bottom half, confirming the increased density in the lower half of the picture space. The right half contained an almost equal number of points (1271; 51.2%) to the left half (1211; 48.8%). The central four squares contained 322 (13.0%) of the points, despite representing only 6.25 percent of the total area; similarly the central sixteen squares contained 1206 points (48.6%) although being only 25 percent of the area. The outer rim of twenty-eight squares contained only 430 points (15.35%) and yet represented 43.7 percent of the total area.

Discussion

The results of Experiment 1 need not be considered in detail. Suffice it to say that they provide a series of stimuli for Experiment 2, and they confirm that subjects are, if not completely precise, in generally fairly good agreement as to the location of significant compositional points within paintings. That the total pattern of dots was very reminiscent of the eye-movement records made by Yarbus (17) is of interest and suggests that significant points may be capable of operational definition in such terms, particularly in view of the recent work by Molnar [18], which has suggested that primitive primal sketch operators can be important in driving visual scan paths. However it should also be remembered that our subjects had been shown two examples of Yarbus' results whilst their task was being explained.

The predominance of points toward the center of the picture space reflects the tendency described by Friedländer [1, p. 91] whereby "the middle appears as the distinguished position, and toward the sides the importance of the locality grows less," an idea also adopted by Arnheim [8] who discusses "the power of the centre." Such centrality is an inevitable part of the triple role of a pictorial frame in emphasizing what Puttfarken [19] has called "Centrality, Frontality and Closeness."

The slight excess of points to the right of center is in contradiction to the suggestion of Adair and Bartley [20], Bartley and Dottardt [21], and Nelson and MacDonald [22] that the left half of a picture is more salient than the right half,

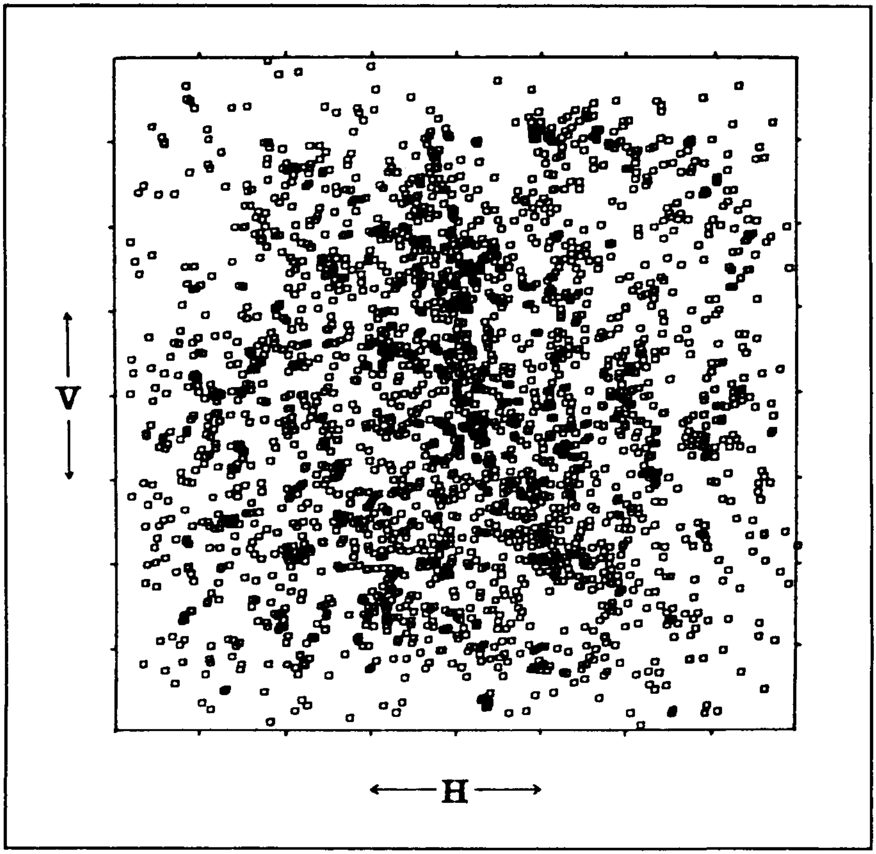

Figure 2. Shows a scattergram of the significant points marked by all ten subjects in Experiment 1 on all of the forty-eight pictures. The vertical (V) and horizontal (H) dimensions of each picture have been independently re-scaled so that the horizontal and vertical axes of the figure represent the entire range for each picture.

although it is possible that this effect is due to different type of judgment being made in the studies.

EXPERIMENT 2

Experiment 2 considered the relative preference of subjects for pairs of pictures and stimuli based upon the significant points in the pictures, within one member of each pair being intact and the other a cut version of a (different) picture.

Method

Fifty subjects took part, the majority being undergraduates in the University of London. None had been told the rationale behind the experiment, and all were unpaid volunteers. No attempt was made to balance for age, sex, or the level to which art had been studied. Subjects first carried out Experiment 2a, in which artificial stimuli were shown and then carried out Experiment 2b, in which pictures were shown. For purposes of analysis and description, it will however be easier to report the experiments in the reverse order.

Stimuli

In Experiment 2b subjects saw twenty-four pairs of pictures. In each pair, two of the postcards used in Experiment 1 were mounted side-by-side on a piece of black card 30 cms high by 40 cms wide. Pictures in a pair were matched as far as possible for style, general subject matter, historical period, and overall coloring, and in many but not all cases both pictures were by the same artist. Appendix 1 lists the pictures used. In each pair of pictures, one had been modified by chopping between 7.8 and 29.1 percent (mean = 15.4%; SD = 8.7%) from the right (N = 13), left (N = 15), top (N = 13) or bottom (N = 7) of the picture. The chopping was carried out so that no major features of the picture were interfered with (for instance a person's head was not cut horizontally). Two series of stimuli were produced: In one of the series, one of the stimuli in each pair was cut and the other intact, and in the other series the reverse combination was given. Each subject saw either one series or the other. The location of the cut picture for the first series was determined randomly, and the position of the cut picture in the second series was the complement of that in the first series, pictures remaining on the same side in each series.

In Experiment 2a the design was identical to that in Experiment 2b with the exception that the stimuli consisted not of the pairs of pictures but rather of pairs of stimuli in which each stimulus consisted of black dots on a white background, dots being 2 mms in diameter and being placed on white card the same size as the original postcard. The white cards were placed on a black background as before. Dots were placed wherever any of the subjects in Experiment 1 had indicated a significant point, with the minor exception that if two dots were over-lapping then one was omitted. As in Experiment 2b, one stimulus in each pair consisted of a chopped picture and the other of an intact picture.

Instructions

In Experiment 2a subjects were told:

> In this experiment I am going to show you a series of pairs of 'pictures', each of which consists of a series of black dots on a white background.

> Your task is to look at the two 'pictures' in each pair and to decide which you think has the better composition. By composition we simply mean which layout of the dots seems to be better integrated, and as a result the image seems to be more satisfying.
>
> There are no right or wrong answers to such a question; it is simply a matter of taste, of aesthetic judgement, and in such matters people will differ.
>
> Please show your decision by indicating on the response sheet whether you feel the composition of the left-hand, is *very much* preferred to the right-hand, is *much* preferred, or is *slightly* preferred, or alternatively that the right-hand picture is *slightly, much* or *very much* preferred to the left-hand picture.
>
> Please mark *one* of the possible responses for each of the *pairs* of images.
>
> Please note that there is no entirely neutral response available. At the very least you must have some minimal preference for one image over the other. If you really feel that you are completely indifferent then simply guess. Do not leave any of the answers blank.
>
> Please do not take too long in making each judgement. It is your immediate rather than considered judgement which interests us. As a rough guide do not take more than 10 to 15 seconds in making each judgement.

After carrying out Experiment 2a subjects were given the instructions for Experiment 2b:

> In the second part of this experiment, I am going to show you a series of pairs of works of art. Your task is to look at each pair and to decide which picture you think has the better composition.
>
> By composition we mean the same thing as you were judging in the previous experiment. Please do *not* make your judgement in terms of the particular subject matter of the picture, of the colouring or of the painter's style. It is *only* the composition which should influence your judgement.
>
> Once again there are no right or wrong answers to such a question.

Subjects were then given similar instructions as before one the use of the six-point scale for indicating their preference, and were also instructed that we wanted them to indicate for each of the pictures whether they had *definitely, probably, possibly* or *never* seen it before.

Finally subjects were asked to complete an Eysenck Personality Questionnaire (EPQ), and to complete a brief questionnaire describing their interests in the arts.

Subjects were debriefed after the experiment, and in particular it was noted whether subjects had spontaneously noticed that some of the paintings had had portions removed from them.

A typical experimental session lasted between thirty and forty-five minutes, and subjects were tested in groups of from one to four persons.

Results

Consider Experiment 2b first. Let a pair of pictures P and Q be presented. Each subject saw either picture P (intact) with Q (Chopped) or P (chopped) with Q (intact). Although it is possible that picture P (intact) may intrinsically have a superior composition to Q (intact), and hence overall will be preferred to it, we may examine a preference for intact pictures over chopped pictures by averaging across the two types of pairs presented, since equal numbers of subjects saw each type of pair.

Taking all judgments, and giving a score of +5 for a *very much* preference for the intact picture, +3 for a *much* and +1 for a *slightly* preference, and –1, –3 and –5 for preferences for the chopped picture, the average score for preference for the uncut over the cut version for all subjects for each pair was +.23, with a standard error (*SE*) of .09 and range of –1.58 to +1.83. The mean is significantly greater than zero ($t = 2.49$, $p < .05$) and hence we may conclude that subjects prefer the complete version of pictures. Examination of the distribution of scores for each subject (see Figure 3) did not show any obvious evidence for separate sub-groups of subjects, some of whom could carry out the task and others could not. Pictures were also considered individually to determine whether in any pairs it was particularly easy to discriminate between intact and cut versions; no evidence for this was found (see Figure 4). An important possibility is that subjects are actually preferring the intact versions not because of their superior composition, but because they have seen them before. A further analysis was therefore carried out in which subject mean scores were calculated for all those pairs in which the subject reported that they had "Never" previously seen either of the pictures. The mean of these scores across subjects was +0.32 ($N = 46$, since 4 subjects claimed to recognize at least one picture in each pair); the mean score is significantly different from zero ($t = 2.18$, $p < .05$), indicating that the preference for uncut versions could not be attributed simply to memory.

Analysis of the dot stimuli of Experiment 2a was carried out by a similar method to that used for the picture stimuli. Once again a score was calculated for each subject. The mean score for all subjects was +.19 ($SE = 0.07$, range = –1.08 to +1.08) the mean being significantly different from zero ($t = 2.59$, $p < .05$), indicating that subjects preferred the dot stimuli derived from intact pictures over those derived from cut pictures. As before, an analysis of the scores for individual pairs of stimuli and individual subjects revealed no evidence for particular sub-groups of stimuli or pictures which were particularly easy to detect (see Figures 3 and 4).

Since the pairs of dot stimuli used in Experiment 2a were derived from the same pairs of picture stimuli used in Experiment 2b, those pairs of pictures for which the discrimination of intact and cut pictures is particularly easy should also be those

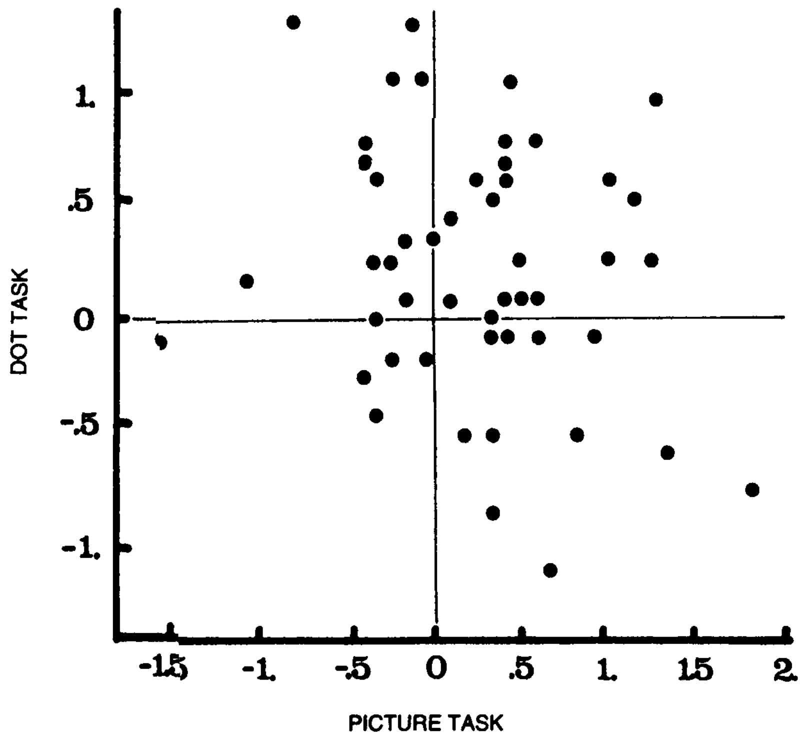

Figure 3. Shows the success of the fifty subjects in Experiment 2 at discriminating cut from uncut versions of the pictures both for actual pictures (x-axis) and dot versions of the pictures (y-axis)

pairs for which the discrimination of intact and cut dot versions is also particularly easy. Figure 3 shows the relation between the ease of detection of the intact version in the two conditions. The correlations between the judgments is –0.12 (N = 24), which is not statistically different from zero. A similar analysis of the differences between subjects in their ability to discriminate between intact and cut versions (Figure 4) shows that there is no significant correlation (r = –.19, N = 50, *ns*) between a subject's performance on the two separate tasks.

The final analysis was carried out to discover whether those eighteen subjects who noticed that a number of the pictures had been cut performed differently from the thirty-two subjects who had not so noticed. Aware subjects were *less* likely to prefer the intact versions than were unaware subjects (mean scores: aware (–.07; SE = .14); unaware (.39; SE = .11)), and within the aware group there was no significant evidence for them preferring the uncut to the cut versions.

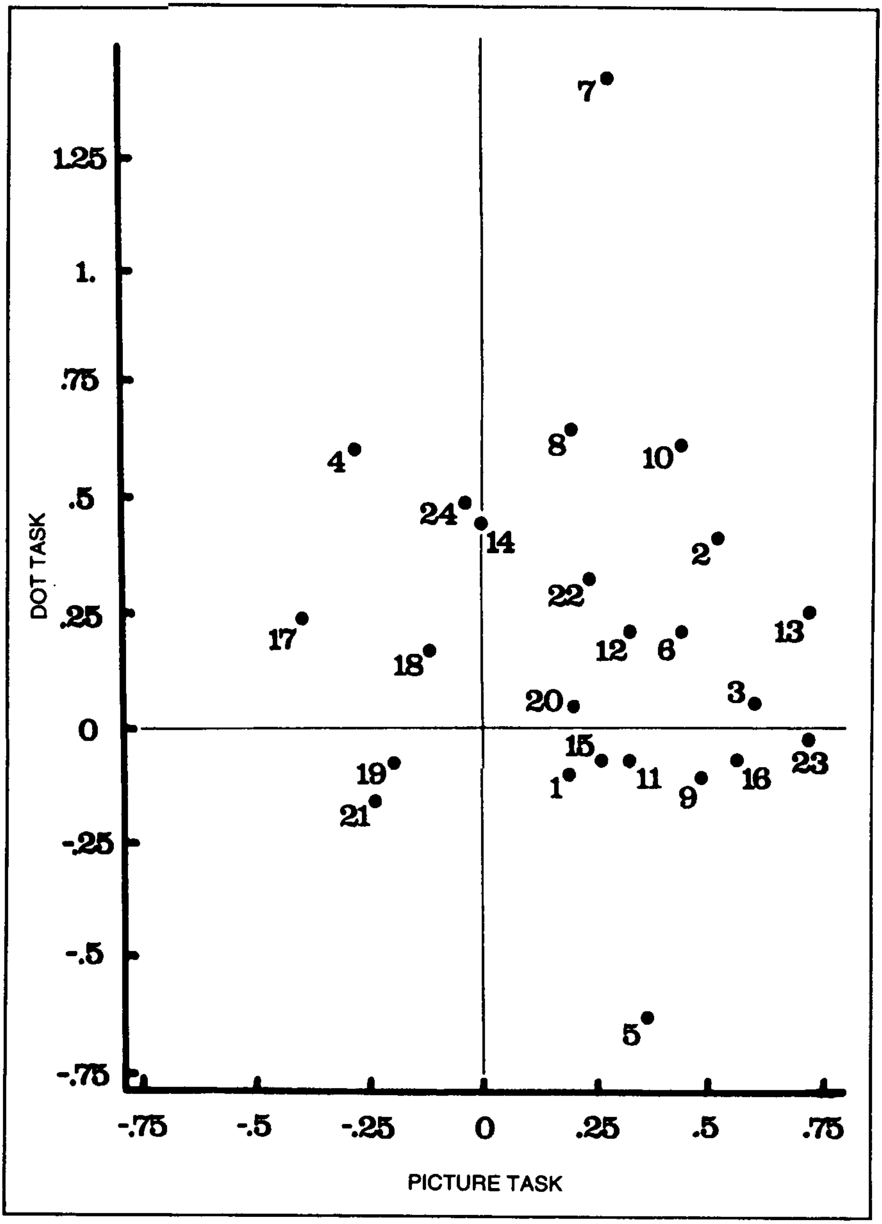

Figure 4. Shows the ease with which the cut and uncut versions of the twenty-four pairs of pictures were discriminated, both for actual pictures (x -axis) and for dot versions of the pictures (y-axis). Numbers alongside points correspond to those in the appendix.

Furthermore, a similar relationship was found when the aware subjects had been considering the dot stimuli, (mean scores: aware = .08 (SE = .14; unaware = .26 (SE = .09)). Repeated measures analysis of variance found a main effect of awareness ($F(1,48) = 9.95, p < .005$), but no significant effects of type of stimulus ($F(1,48) = 0.08$, *ns*) or of an interaction between stimulus type and awareness ($F(1,48) = 1.17$, *ns*), implying that the difference between the aware and unaware groups was the same for the two sets of stimuli.

Correlations were examined between the measures of performance on the two tasks and on twenty-two background measures, including the four personality measures of the EPQ, age, sex, and a number of measures on interest, activity and education in the various arts. Only two correlations out of forty-four were significant at the 0.05 level, and this rate of 4.5 percent suggests that those two results represented type 1 statistical errors and could not be regarded as statistically significant. It was concluded that none of our background measures could predict success on the task.

Discussion

The results of Experiment 2b show that the subjects apparently are able to distinguish the original version of a picture from one in which a portion has been removed, and the analysis of just those pairs of pictures in which a subject has seen neither picture before suggests that this ability is not a result of simple memory for pictures (in contrast to the results of Blount et al. [23], in which memory alone could explain the subjects ability to distinguish original from transformed versions of the pictures). Furthermore the fact that subjects are capable of carrying out a similar task for stimuli derived from the significant points of pictures might be thought to suggest that subjects are indeed carrying out the task by examining the geometric composition of the images, be they picture or dot stimulus. That conclusion however encounters severe difficulties when it is found that neither for pictures nor for subjects is there evidence for a correlation between performance on the pictorial and dot versions of the same pairs of stimuli. That result seems to force the conclusion that different information is being used for the two tasks; and since the only information *common* to the two tasks is the positioning of significant points in relationship to one another and to the frame, then in neither experiment can geometric composition be the crucial information for distinguishing intact from cut versions. Such a conclusion is partially supported by the surprising finding that those subjects who were aware that some pictures had been cut (and who perhaps might be credited with greater pictorial knowledge, feeling or insight) did *not* prefer the intact to the cut versions; furthermore the latter group's lack of preference could not have been due to a biased perception due to knowledge that the pictures had been interfered with, since the identical result was also found for the dot stimuli, which were seen before the pictures, and at a stage when it is highly unlikely that the subjects could have been aware that some of the dot patterns had been derived from cut versions of recognizable pictures.

The problem of course still remains as to how subjects were able to distinguish intact from cut stimuli. The first thing that must be emphasized is that the effect is small, being equivalent to being correct on 13.5 times out of twenty-four instead of a chance expectation of twelve occasions. The most likely explanation in the case of the pictures is that subjects noticed minor inconsistencies in the cut pictures, such as a person or a building in the background who has been cut in half and hence looks like a result of bad composition. For the dot versions the best explanation is that in cut versions significant points tend to be nearer to the edge, and hence either look less well placed, or perhaps just look less typical, given the distribution of Figure 2. Such hypotheses are of course open to further testing.

A final problem of interpretation of Experiment 2 lies in the possibility that paintings that we have interpreted as being whole may at some previous time have been cut out of a still larger work, either by the artist or some other person. After carrying out Experiment 2 it was discovered that this was indeed precisely the case for pictures 1a and 1b by Manet [see 24], although in this case the hypothesis of an implicit compositional geometry could perhaps be saved by arguing that since the pictures had been cut by the artist himself then he had done so in precisely such a way as to retain an implicit geometry.

EXPERIMENT 3

The results of Experiment 2 suggest strongly that subjects do not use information concerning compositional geometry in order to make aesthetic decisions. That conclusion is however slightly weakened by the existence of slight preferences for the uncut over the cut versions. Experiment 3 was designed to circumvent such problems by using totally synthetic stimuli in which there was far greater control over the stimuli. In each pair of stimuli, one item had a strict geometrical structure, whereas the other consisted of a degraded and thereby non-structured version of the geometrically structured stimulus.

Method

Sixteen subjects, all of whom were pre-clinical students at St. Mary's Hospital Medical school, took part. All were unpaid volunteers, who were not told the rationale of the experiment beforehand, and were tested in a single large group, the stimuli being projected by an overhead projector.

Stimuli

Each subject saw fifty pairs of stimuli. In each pair, one stimulus was highly structured. A frame of vertical:horizontal ratio of 1.3:1 was constructed, and a number of square black elements placed within it, each element lying on one of the construction lines joining all possible combinations of the four corners and the four mid-points of the sides. Elements were placed randomly along these lines, with the constraint that they did not lie closer than 0.1 of the total width/height to the edge (this was designed to approximate the paucity of genuine significant points which occurs in real pictures near the edges—see Figure 2). The elements in the non-structured stimulus were placed by taking each element in the structured stimulus and randomly moving it within an ellipse of radius 0.1 of total width/height. As before, elements were not allowed to fall within 0.1 of width/height of the edge. The control or non-structured stimuli therefore have the property that, to a first approximation, the first and second order two-dimensional statistics are equivalent (or, to put it another way, stimuli differ primarily in high spatial frequency components), so that preference cannot be expressed primarily for overall positioning of the elements. It is therefore the detailed configural relationships of the points to each other and to the edges which have been disrupted.

Stimuli contained either eight, sixteen, thirty-two, sixty-four or 128 elements. Each subject saw ten versions of each number of elements. The area of the elements was reduced as the number increased such that the total area of black within the frame remained constant. Figure 5 shows examples of the stimuli. As an illustrative example, Figure 5 also shows a stimulus with 2000 points, to emphasize the implicit structure, and to show its effective disruption by the randomization process (this figure was not, of course, used as an experimental stimulus). In the half the pairs the structured stimulus was on the left and in the remaining half on the right. The order of presentation of stimuli was randomized.

Stimuli were drawn on a flat-bed graph plotter under computer control, and then photocopied onto transparent sheets and shown on an overhead projector. Each stimulus was presented for about ten seconds.

Instructions

These were almost identical to those given in Experiment 2, with a few minimal changes of wording as appropriate. Subjects responded by making preference judgments for the right or the left-hand stimulus on a six-point rating scale. Neutral or "no preference" responses were not allowed.

The experiment lasted approximately fifteen minutes, after which subjects were questioned as to their reactions to the experiment, and its supposed purpose, and were then fully debriefed. No subjects had perceived the hidden structure of the stimuli, although in the cases of stimuli containing many elements, some subjects had noticed the occasional presence of straight line relationships between elements (see, e.g., Figure 5e).

Results

Judgments were analyzed in two forms; as six-point responses, by means of analysis of variance, or as two-point responses, simply recording whether the right

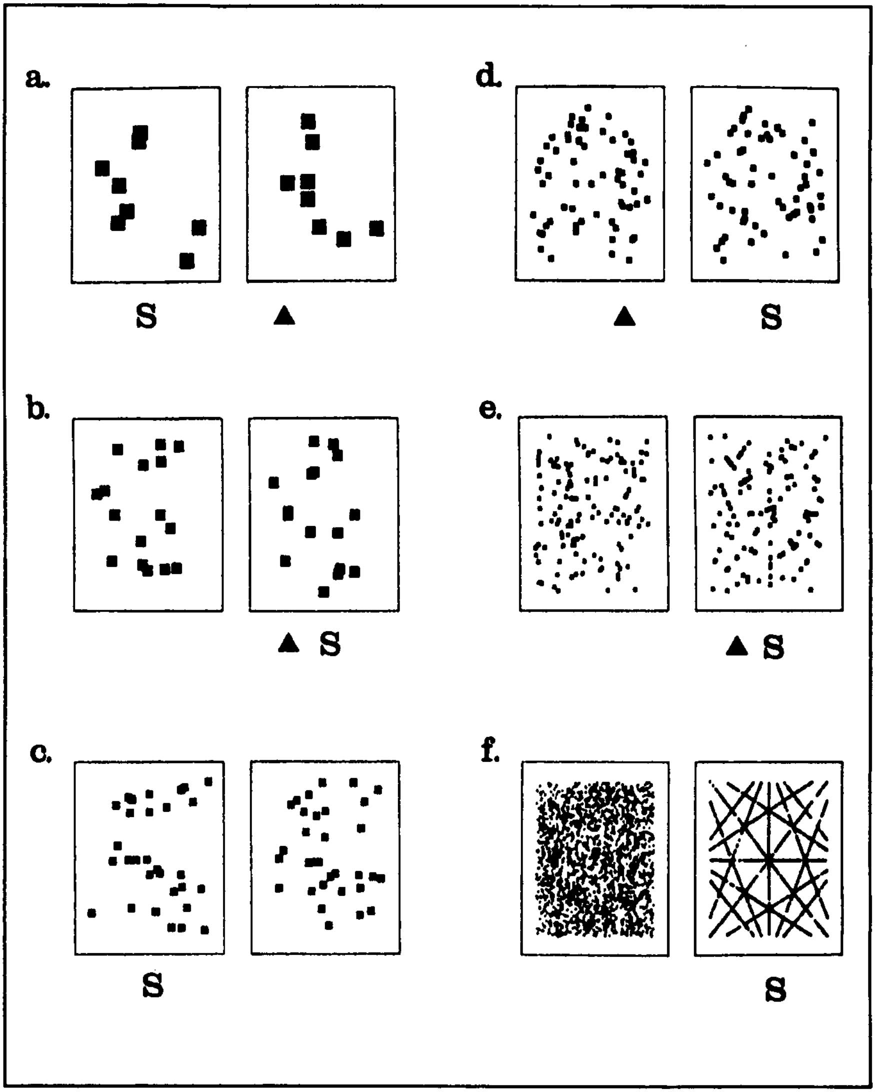

Figure 5. Shows examples of the stimuli used in Experiment 3. Figures 5a-e show stimuli with 8, 16, 32, 64, and 128 elements respectively. Figure 5f shows an illustration of a stimulus with 2000 points to demonstrate the latent structure underlying the points. In each pair, the letter S indicates the structured stimulus. In pairs a, b, d, and e the solid triangle points toward the stimulus which was the more preferred of the pair, in each case preferences being significant at the 0.05 level on an individual *t*-test. Stimulus 5c showed no relative preference at all between the items.

or the left-hand stimulus was preferred. All responses were transformed prior to analysis so that they referred to preference for structured/non-structured stimulus rather than to right or left-hand stimulus.

Sixteen subjects each saw fifty pairs of stimuli. Of the 800 preference judgments, 388 (48.5%) were for structured stimuli, a proportion which is not significantly different from chance expectations of 50 percent (Chi-squared = 0.72, 1 df, *ns*). Judgments on the six-point scale were analyzed by one-way repeated measures analysis of variance, scaling the judgments as in Experiment 2 (+5 for a strong preference for the structured stimulus, though +3, +1, –1 and –3 to –5 for a strong preference for the non-structured stimulus). The mean score for the 800 stimuli was –0.06, which is not significantly different from zero ($F(1,735) = 0.04$, *ns*) indicating an absence of any overall preference for structured stimuli. However there were significant differences in preference between stimulus pairs ($F(15,735) = 2.50$, $p < .001$), indicating that subjects showed consistent preferences within pairs, but that these preferences were unrelated to which item was structured. Preferences for structured stimuli were not related to the number of elements in the stimuli, the structured stimulus being preferred in 48.8 percent, 49.4 percent, 50.6 percent, 40.0 percent, and 53.8 percent of pairs with eight, sixteen, thirty-two, sixty-four and 128 points respectively. Figure 5 shows examples of stimuli for which there were strong preferences within pairs, both for structured and non-structured stimuli. Figure 6a shows the number of stimulus pairs in which the structured item was preferred by various numbers of subjects, and compares the distribution with that expected under a binomial distribution. There is a small excess of extreme stimuli over that expected by chance. Subject differences may be compared if the Subject × Stimulus interaction is regarded as an acceptable error term. Subjects showed highly significant differences in their preferences for structured rather than non-structured stimuli ($F(15,735) = 4.18$, $p < .001$). Figure 6b shows the numbers of subjects showing particular proportions of preferences for structured stimuli, and compares them with binomial expectations; again there is some slight evidence for an excess of extreme cases over the expected.

It should be noted that in the analysis of variance only 2.9 percent of total variance is attributed to subject differences, and 11.9 percent to stimulus differences, the remaining 85.1 percent being confounded subject × stimulus interaction and error of measurement.

Discussion

Experiment 3 shows that there is little evidence that subjects in general show preferences for structured over non-structured synthetic stimuli. There is however some evidence that subjects differ in their relative preferences for structured stimuli, and it is therefore conceivable that a more aesthetically sensitive group of subjects might show overall preferences for structured stimuli, although this does

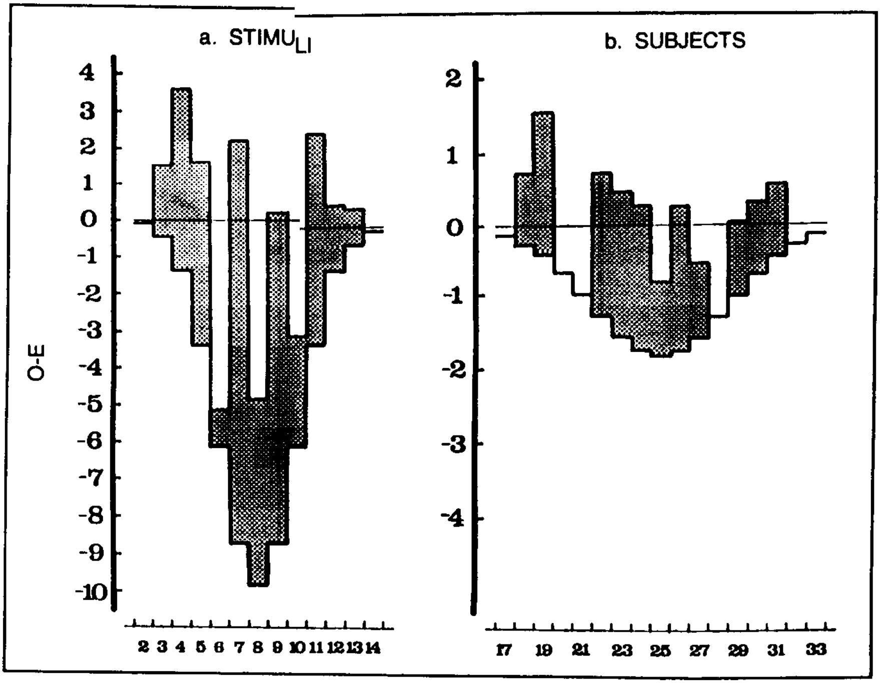

Figure 6. a) Shows the numbers of individual stimulus pairs for which there were particular numbers of preference for the structured stimulus, as compared with the expectation under a binomial hypothesis. b) Shows the numbers of subjects with particular numbers of preferences for the structured stimulus, and the expectation under a binomial hypothesis. Figures are plotted according to the method of Wainer and Thissen [25], with the expected distribution being plotted as a continuous line below the abscissa, and with the histogram being plotted upon those expected values, so that differences between observed and expected values are readily apparent.

not seem likely in view of the small size of the effect. It is also possible that using a larger number of points, in which the geometrical structure would have been clearer (of which Figure 5f is an extreme case), would have resulted in a different conclusion. However, it should also be said in such a case that it would no longer be an implicit, latent geometric structure which was being preferred, but an explicit, actual structure, which is not the case in paintings supposedly using compositional geometry.

CONCLUSIONS

Together the results of these experiments throw considerable doubt upon hypotheses of the implicit detection of latent compositional geometry as a major component of aesthetic judgments, at least for relatively unsophisticated observers. It is of course a separate question as to whether such compositional geometry is used explicitly by artists whilst creating works.

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APPENDIX 1:

Pairs of Pictures Used as Stimuli in Experiments 1 and 2. For each stimulus is also shown the side and the percentage that was removed when the cut versions were presented.

Pair:	Artist	Title	Gallery	Side and Percent
1a	Manet	Un bar aux Folies Bergere	CI	L 17.5%
1b	Manet	The waitress	NG	B 21.9%
2a	Claude	Landscape: Aeneas at Delos	NG	L 23.8%
2b	Claude	The enchanted castle	NG	L 20.4%
3a	Leger	Two women holding flowers	TG	R 25.3%
3b	Leger	The acrobat and his partner	TG	R 22.7%
4a	Pissarro	The Avenue, Sydenham	NG	R 22.3%
4b	Pissarro	View of Louvenciennes	NG	R 21.6%
5a	Vermeer	A young woman standing at a virginal	NG	L 20.6%
5b	Vermeer	A young lady seated at a virginal	NG	T 27.9%
6a	Cezanne	Mountains in Provence	NG	T 11.1%
6b	Cezanne	The grounds of the Chateau Noir	NG	L 20.1%
7a	Klee	A young lady's adventure	TG	L 13.4%
7b	Klee	Comedy	TG	R 16.9%
8a	Titian	Portrait of a man	NG	T 14.5%
8b	Titian	Portrait of a lady	NG	B 7.8%
9a	Whistler	Nocturne in Blue and Gold: Old Battersea Bridge	TG	R 13.4%
9b	Whistler	Nocturne in Blue-Green	TG	L 21.1%

APPENDIX 1 (Cont'd)

Pair:	Artist	Title	Gallery	Side and Percent
10a	Uccello	St. George and the dragon	NG	T 15.3%
10b	Uccello	Niccolo Mauruzi da Tolentino at the battle of San Romano	NG	L 26.0%
11a	Utrillo	Le Passage Cottin	TG	L 29.1%
11b	Utrillo	La Place du Tertre	TG	T 15.6%
12a	Turner	Snow storm: Steam-boat off a harbour's mouth	TG	L 20.3%
12b	Turner	Norham Caslte, Sunrise	TG	R 15.0%
13a	Rembrandt	Jacob Trip	NG	B 21.2%
13b	Rembrandt	Self Portrait, aged 63	NG	L 25.0%
14a	Matisse	The Snail	TG	B 14.2%
14b	Heron	January	TG	L 13.1%
15a	Canaletto	Venice: Upper reaches of the Grand Canal with San Simeone Piccolo	NG	T 18.8%
15b	Canaletto	Venice: The basin of San Marco on Ascension Day	NG	T 13.6%
16a	Warhol	Marilyn	TG	R 23.5%
16b	Warhol	Chairman Mao	TG	L 18.7%
17a	Constable	Salisbury Cathedral from The Meadows	NG	L 16.2%
17b	Constable	The Cornfield	NG	T 15.5%
18a	Degas	Beach scene	NG	B 16.1%
18b	Steer	Boulogne Sands	TG	R 14.8%
19a	Lowry	The Pond	TG	T 24.2%
19b	Lowry	Industrial landscape	TG	T 22.4%
20a	Corot	The Waggon: souvenir of Saintry	NG	T 19.5%
20b	Corot	The leaning tree-trunk	NG	R 16.6%
21a	Sargent	The black brook	TG	T 23.4%
21b	Morisot	Summer's day	NG	R 19.4%

APPENDIX 1 (Cont'd)

Pair:	Artist	Title	Gallery	Side and Percent
22a	Sutherland	Entrance to a lane	TG	B 21.5%
22b	Sutherland	Horned forms	TG	T 16.3%
23a	Monet	Lavacourt: Winter	NG	B 21.7%
23b	Monet	The Thames below Westminster	NG	R 10.4%
24a	Matisse	Standing nude	TG	L 24.7%
24b	Matisse	Nude study in blue	TG	R 15.3%

Key: NG: National Gallery, London; TG: Tate Gallery, London; CI: Courtauld Institute Galleries. T: Top; B: Bottom; R: Right; L: Left.

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