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Skin conductance and aesthetic evaluative responses to nonrepresentational works of art varying in symmetry

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Skin conductance was recorded as 11 subjects judged the aesthetic potential of abstract works of art and their single- and double-axis symmetrical transformations. It was found that the more structurally complex asymmetrical originals elicited higher levels of arousal than the less complex single-axis symmetrical transformations, which elicited greater arousal than the double-axis transformations. Subjects' ratings of the hedonic value of the compositions were directly related to the arousal increment gained from viewing the stimuli. The results are discussed in terms of Berlyne's (1960) theory of aesthetic behavior regarding the relationship among complexity, arousal, and hedonic value.

A substantial body of research supports Berlyne's (1960, 1971) contention that the behaviors involved in the encoding and processing of visual stimuli occur as part of a comprehensive "orientation reaction" to the information content of patterns. This orientation reaction consists of a set of psychophysical changes, indicative of a rise in arousal, that accompany visual exploration.

Complexity is one property of a visual display that contributes to its arousal potential. Berlyne (1960) defined complexity in terms of three dimensions: the number of elements in a display, their dissimilarity, and the degree of irregularity in their arrangement. When symmetry is introduced into an asymmetrical visual display, the number of nonredundant elements contained in the transformation is reduced, as is irregularity. The transformed display becomes less intricate and less laden with information than the asymmetrical original. According to Berlyne, this difference in complexity should be reflected in both the exploratory behaviors and the arousal potential associated with the orientation reaction generated by the asymmetrical display and its symmetrical transformation.

Symmetry, a frequent variable in studies of form perception, has consistently been shown to influence the encoding of visual stimuli. For example, the presence of symmetry in a pattern can be detected more quickly than its absence, and some types of symmetry, such as vertical, are more readily detectable than others (see, e.g., Bruce & Morgan, 1975). Evidence of this symmetry effect, however, is indirect; that is, it is based on reaction time and performance outcomes in symmetry detection and recognition tasks. Very little attention has been paid to the exploratory behavior associated with the orientation reaction that mediates the evaluative and performance effects of symmetry. And we know of no research that has systematically investigated the relationship between the number of redundant symmetrical details contained in complex visual displays and their arousal potential.

Research by Locher and Nodine (1987) provides evidence that the presence and type of symmetry in a stimulus influence visual exploration. Eye movements of subjects were recorded as they judged the aesthetic value of asymmetrical nonrepresentational paintings and their single- and double-axis symmetrical tranformations. Locher and Nodine found that when single-axis symmetry was present, both short-dwell survey fixations and long-dwell examination fixations were concentrated on the paired details along the axis of symmetry, regardless of whether the axis was horizontal or vertical. When a display was symmetrical about both axes, fixations tended to be directed to the features in the central region of the composition, and to paired details along only one of the axes. When symmetry was absent, however, exploration was more evenly distributed to all areas of the display. Differences in exploration of the asymmetrical original and its symmetrical transformations reflect differences in complexity and regularity and demonstrate that symmetry influences visual exploratory behavior associated with the orientation reaction.

According to Berlyne's (1960) explanation of the motivational effects of information content on the orientation reaction, arousal potential of the original paintings and symmetrical transformations studied by Locher and Nodine (1987) should also be related to the differences in complexity between the types of display. In the present research, an index of the effect of symmetry on level of physiological arousal was obtained by measuring the skin conductance changes (galvanic skin response, or GSR) elicited by these stimuli as subjects judged their hedonic value. It was anticipated that the results would provide evidence of symmetry's influence on the arousal component of the orientation reaction. The nature of the effect, however, could not be predicted on the basis of previous findings, because the relationship between complexity of visual stimulation and arousal potential remains unclear in the literature. Furthermore, the dimensions of stimulus complexity responsible for the complexity effect on arousal potential have yet to be clarified.

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For example, researchers using experimentally derived geometric figures and checkerboard-like patterns have reported that increasing the number of elements (or amount of material) in a visual display leads to a linear increase in arousal as measured by both GSR (e.g., Berlyne, Craw, Salapatek, & Lewis, 1963) and electroencephalography (EEG) (e.g., Christie, Delafield, Lucas, Winwood, & Gale, 1972). Increasing the variety or heterogeneity of elements in such stimuli, however, has little effect on arousal (e.g., Christie et al., 1972). When stimuli contain a large number of elements and their range of complexity is broad, arousal has been found to be an inverted U-function of complexity. Nicki and Gale (1977) reported such a relationship between EEG arousal and low, medium, and high levels of subjective complexity of 18 nonrepresentational works of art.

Previous findings, therefore, have demonstrated that the arousal potential of visual stimuli is a function of complexity. The nature of this relationship and the dimensions of complexity that contribute to the arousal potential of a visual display, however, need additional investigation. The stable finding of a systematic symmetry effect upon detection and recognition task performance suggests that symmetry is one aspect of complexity that influences arousal. In the present study we sought evidence of the influence of symmetry on the arousal potential of multidimensional nonrepresentational visual displays.

Berlyne (1974) stated that the evaluative aspects associated with the appreciation of art (e.g., pleasingness, desire to own) are related to the arousal potential of artworks, to which complexity is a contributing factor. Whether it is the arousal itself or the arousal reduction that is pleasurable, arousal potential is intrinsically bound up with complexity and aesthetic preference, according to Berlyne. This assertion was tested in the present study. After viewing each composition, subjects rated it on a 5-point scale for inclusion in a hypothetical art show. It was predicted that hedonic ratings would be highest for the originals, lower for the single-symmetry transformations, and lower still for the double-symmetry transformations, reflecting the complexity and, correspondingly, the arousal potential of each type of display. Furthermore, it was anticipated that hedonic value of the stimuli would be directly related to the amount of arousal resulting from viewing the artworks.

METHOD

Subjects

Eight female and 5 male undergraduates, none of whom had had any formal training in art, volunteered as subjects.

Stimuli and Apparatus

The stimulus set consisted of 15 original nonrepresentational works of art and 8 experimentally derived symmetrical transformations. Abstract artworks were chosen because realism might have interfered with the experimental manipulation of the stimuli and with subjects' judgments of hedonic value.

Twelve of the stimuli were those used by Locher and Nodine (1987). This subset consisted of slides of four asymmetrical abstract paintings—Hoffman's *The Golden Wall* (1961), Duchamp's *King and Queen Surrounded by Swift Nudes* (1912), Klee's *Roseraie* (1920), and Pollock's *Seven* (1950)—and two symmetrical transformations of each painting. Color photographs of the paintings were digitized using a DeAnza image-array processor serviced by a LSI 23 computer. Each of the stored images was transformed by reflecting one half of the display to create a symmetrical image about the central axis, and by reflecting the bottom left quarter to create a symmetrical image about both the x- and y-axes. One painting and its transformations are shown in Figure 1.

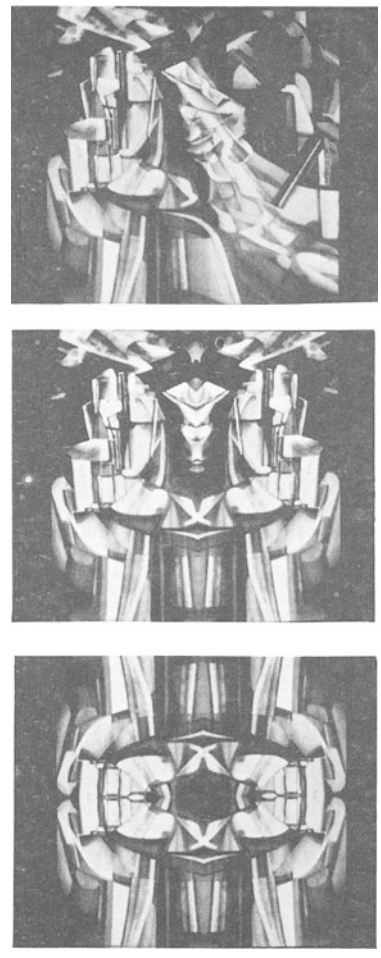

Figure 1. Duchamp's *King and Queen Surrounded by Swift Nudes*: original (top), single-symmetry transformation (middle), and double-symmetry transformation (bottom).

To increase the size of the stimulus set and to aid in randomization, slides of an additional 11 asymmetrical nonrepresentational paintings were included in the set. These paintings were chosen because they were similar in general level of complexity to the four paintings used by Locher and Nodine (1987), and because they had been found to produce GSRs in studies of aesthetic phenomena by Sargent-Pollock and Konečni (1977) and Wohlwill (1968). These 11 paintings were Rothko's *Untitled* (1949), Vasarely's *Our* (1956), Braque's *La Roche-Guyon (1909), Matisse's Porte-Fenêtre à Collioure* (1914), Diebenkorn's *Ocean Park No. 66* (1973), Stills's *1954* (1954), Mondrian's *Flowering Apple Tree* (1912), Lissitsky's *Proun ID (1919), Moholy-Nagy's G VIII* (1922), Frankenthaler's *Giant Step* (1975), and Kandinsky's *Little Red Dream* (1925).

The displays, which were projected onto a screen 120 cm from the subject, measured 75 cm in width at the screen and subtended approximately 30° visual angle. Except when a display appeared on the screen, the room was dimly lit by the illumination of the screen by an empty slide from the moment the subject entered the laboratory.

Skin conductance level (SCL) was measured using a Lafayette Instrument Co. Model 7601-A psychogalvanometer, connected to a Varian Associates YT paper chart recorder. A 12-μA constant current was used in the SCL recording. The dependent measure studied was amount of arousal increment gained from viewing each stimulus. A change score for each trial was obtained by subtracting the baseline SCL at the onset

of the stimulus from the highest point of needle deflection for that trial. The ordinate of the recordings measured 100 units of deflection, and the time calibration was 2.5 sec per division.

Procedure

After the subject was comfortably seated facing the screen, GSR electrodes were attached to the palmar surfaces of the second phalanges of the index and ring fingers of his/her right hand, which was placed on the desktop of the chair. The subject was then told that the general purpose of the research was to examine "aesthetic preferences" for abstract art and that he/she would see a set of paintings, some of which were being considered for inclusion in a art show. The subject was instructed to examine each painting carefully and to pay attention to such features as composition, color, complexity, and creativity. Symmetry was not mentioned at any point during the experimental session.

It was further explained that, following the brief presentation of each painting, it was to be evaluated for inclusion in the art show. The 5-point rating scale was as follows: 1 = *poor—definitely do not show, downright boring*; 2 = *borderline—should probably not be shown*; 3 = *fair—some orginality, show only if space available*; 4 = *good—imaginative and creative, show it*; 5 = *excellent—shows exceptional creativity and originality, definitely show it.*

The subject was told that his/her physiological reaction to each painting was being recorded by the GSR apparatus, and the importance of keeping the hand with the attached electrodes as still as possible was emphasized. Baseline GSR was established (a zero reading for at least 5 sec), and then the subject's sensitivity to a sudden loud noise of approximately 95 db SPL was used to calibrate the GSR apparatus to full-scale deflection. A second baseline reading was obtained after the last slide was shown to make certain it did not differ significantly from the initial baseline reading. Excessive movement of the hands of 2 subjects during GSR recording created large disturbances in several of their conductance tracings, and their data were not included in any of the analyses.

Each of the 23 slides, randomly ordered, was shown for 9 sec. A pilot study had demonstrated that observers were ready to rate the paintings after 9 sec of viewing. Following each slide presentation, the subject was given 5 sec to verbally rate the painting.

RESULTS AND DISCUSSION

To what extent did level of symmetry and the particular or composition of the displays influence degree of arousal and hedonic ratings? To answer this question, we performed 3 (levels of symmetry) × 4 (original paintings) repeated measures ANOVAs, with increase in SCL and evaluative ratings as the dependent variables. The means and standard deviations for these data are presented in Table 1.

Data analysis showed a significant main effect of symmetry on arousal increment [$F(2,100) = 488.1, p < .001$]. Average increase in SCL was significantly greater ($p < .01$) for the asymmetrical originals than for the single-axis symmetrical transformations, whose average increase in SCL was significantly greater ($p < .01$) than that for the double-axis symmetrical transformations (Tukey HSD test). Differences in arousal increments among the individual stimuli within each level of symmetry, however, were not significant [$F(3,100) = 1.15$, n.s.], nor was the interaction effect [$F(6,100) = 2.03$, n.s.].

It is clear from these findings that symmetry is an aspect of complexity that influences the arousal potential of multidimensional nonrepresentational visual displays. The symmetrical transformations of asymmetrical paintings contained fewer and less varied nonredundant elements than were present in the originals; correspondingly, their complexity and arousal potential were reduced. Although construction of the symmetrical transformations confounded the two variables of number and variety of elements, we conclude that it was the decrease in number, not variety, of elements that produced the "complexity effect" on arousal. This conclusion is based upon the finding that the average arousal increment was approximately the same for the four stimuli within each level of symmetry. Apparently, the subjective complexity of the stimuli within each level of symmetry was similar, despite differences in the particular structural and formal aspects of each stimulus. Supporting this conclusion is the fact that the four stimuli within each level of symmetry were rated as having approximately the same degree of subjective complexity on a 7-point scale by 21 subjects in a study conducted by Locher and Nodine (unpublished).

Table 1
Means and Standard Deviations for Increases in Skin Conductance Level and Hedonic Ratings as a Function of Level of Symmetry and Artist

	Level of Symmetry						
	Asymmetrical		Single-Axis		Double-Axis		
Artist	*M*	*SD*	*M*	*SD*	*M*	*SD*	Row *M*
	Increase in Skin Conductance Level						
Hoffman	32.8	5.0	17.3	3.4	6.5	1.6	18.9
Duchamp	30.9	6.0	19.3	4.5	5.8	2.1	18.7
Klee	31.0	3.7	18.9	2.3	5.0	3.2	18.3
Pollock	36.4	7.2	18.2	2.7	5.6	2.5	20.0
Column *M*	32.7		18.4		5.7		
	Hedonic Ratings						
Hoffman	4.27	.47	2.91	.54	2.00	1.00	3.06
Duchamp	4.00	.45	3.09	.70	1.36	.67	2.82
Klee	4.45	.69	2.73	.79	1.73	.79	2.97
Pollock	4.18	.75	3.36	.81	1.64	.81	3.06
Column *M*	4.23		3.02		1.68		

Further evidence that the variety of elements among the stimuli had little effect upon arousal potential is provided by the arousal data for the 11 asymmetrical "filler" stimuli. The average arousal increment for these stimuli was 32.8 (range 31.3 to 34.6). This mean value is almost identical to the average change in SCL for the four asymmetrical originals (32.7), and suggests that the subjective complexity of all of the asymmetrical paintings fell within the same approximate range, as intended. It should be noted, however, that the failure to find a significant difference in arousal increments among stimuli in each level of symmetry may reflect a shortcoming of the present study, namely, that the measure of arousal is relatively crude compared with that used in other studies and may have failed to detect differences in arousal potential.

These results are consistent with accumulated evidence that decreasing the number of elements in geometric patterns leads to a reliable decrease in arousal potential, whereas a change in variety of elements has little effect on the arousal potential of such visual displays (e.g., Christie et al., 1972). On the other hand, the finding of a linear relationship between complexity and arousal appears contradictory to the results reported by Nicki and Gale (1977). They found an inverted U-shaped relationship between arousal as measured by EEG and low, medium, and high levels of subjective complexity of 18 nonrepresentational works of art.

The present findings would be compatible with those of Nicki and Gale (1977) if it were assumed that the compositions included in both studies sample a broad range of ob-

jective complexity, and that the stimuli in the present study are restricted to the lower values of this continuum. The double- and single-symmetry transformations are similar in complexity and composition to the experimentally generated geometrical patterns for which a linear relationship between complexity and arousal has been reported (e.g., Berlyne et al., 1963). The low-, medium-, and high-complexity asymmetrical works studied by Nicki and Gale represent intermediate and high values of this continuum. If this assumption is correct, a possible conclusion would be that at lower levels of complexity, arousal is directly related to the complexity of nonrepresentational patterns. Above some optimal degree of objective complexity, however, arousal potential decreases because, as Nicki and Gale suggested, subjects are less able to process the higher information content.

The present results, when put together with the visual exploration data reported by Locher and Nodine (1987) for the same stimuli, suggest that the symmetry effect on reaction time and performance outcomes reported in the literature may be mediated in part by differences in the orientation reaction generated by symmetrical and asymmetrical displays. Because symmetrical arrays have less information content and are less incongruous or more redundant than asymmetrical arrays, they produce less arousal, as demonstrated in the present study. Observers are, it seems, more able to assimilate the information contained in symmetrical stimuli, enabling arousal levels to fall more quickly below a threshold value.

In addition, exploratory inspection of symmetrical displays is facilitated by the presence of paired or redundant details about the axis (or axes) of symmetry. As Locher and Nodine (1987) showed, visual exploration was less extensive for both the single- and double-axis transformations than for the asymmetrical originals. The combined findings of the present study and that of Locher and Nodine demonstrate that the presence of symmetry facilitates two important components of the orientation reaction: visual exploration and arousal potential. This facilitation may be the basis for the frequently reported observation that detection and recognition are faster for symmetrical displays than for asymmetrical displays.

The effect of symmetry on the subjects' hedonic ratings was as pronounced as the effect on physiological arousal. The results of the analysis of the evaluative ratings, which repeat those for the GSR data, showed that ratings were influenced by the presence of symmetry [$F(2,100) = 136.0$, $p < .001$]. Specifically, more complex asymmetrical originals were rated higher than less complex single-axis transformations, which were rated higher than the double-axis transformations (all differences were significant at $p < .01$, Tukey HSD test). This finding is in agreement with the results of other investigations of the relationship between aesthetic preference and judged complexity of nonrepresentational works of art, which show a positive linear relationship between subjective complexity ratings and ratings of "liking" (Wohlwill, 1968) and "interestingness" (Nicki & Gale, 1977).

Like the arousal data, the average hedonic ratings of the four stimuli within each level of symmetry did not differ [$F(3,100) = .82$, n.s.]. Nor was there a significant interaction between level of symmetry and artist [$F(6,100) = 1.45$, n.s.]. This suggests that the hedonic value of these nonrepresentational compositions was influenced by the number of nonredundant elements, not the variety of elements contained within the stimuli.

Finally, the relationship between the arousal potential of the stimuli and their hedonic value was examined. According to Berlyne (1971), a rise in arousal is pleasurable, provided the increase is not enough to drive arousal into an upper range that is aversive and unpleasant. Is it this rise in arousal that produces the hedonic effect? To test this, we calculated intrasubject correlations (Spearman rank test) between SCL increments and hedonic ratings for the 12 stimuli. The correlation coefficients for the 11 subjects were .95, .90, .90, .90, .81, .80, .80, .79, and .72 (all significant at $p < .005$); .68 ($p < .01$); and .59 ($p < .025$). These values are all positive and high, supporting Berlyne's contention that the hedonic value of stimuli of low and intermediate levels of complexity is directly related to the amount of arousal generated by the visual exploration of such stimuli.

In sum, the present results shed light on the mechanisms by which symmetry influences visual perception, and they support Berlyne's (1971) theory of aesthetic behavior. They demonstrate that symmetry is one aspect of stimulus complexity that determines the intensity of the physiological arousal component of the orientation reaction generated by a visual display, and, correspondingly, its hedonic value. When symmetry is introduced into an asymmetrical display, the stimulus complexity of the decreases, information-processing demands are reduced, and arousal potential is lowered. The extent of this effect will most likely vary with populations, circumstances, and the complexity and amount of realistic content contained in a stimulus.

REFERENCES

Berlyne, D. E. (1960). *Conflict, arousal and curiosity*. New York: McGraw-Hill.

Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York: Appleton-Century-Crofts.

Berlyne, D. E. (1974). *Studies in the new experimental aesthetics*. Washington, DC: Hemisphere.

Berlyne, D., Craw, M., Salapatek, P., & Lewis, J. (1963). Novelty, complexity, incongruity, extrinsic motivation, and the GSR. *Journal of Experimental Psychology*, **66**, 560-567.

Bruce, V., & Morgan, M. (1975). Violations of symmetry and repetition in visual patterns. *Perception*, **4**, 239-249.

Christie, B., Delafield, G., Lucas, B., Winwood, M., & Gale, A. (1972). Stimulus complexity and the EEG: Differential effects of the number and variety of display elements. *Canadian Journal of Psychology*, **26**, 155-170.

Locher P., & Nodine, C. (1987). Symmetry catches the eye. In J. K. O'Reagan & A. Levy-Schoen (Eds.), *Eye movements: From physiology to cognition* (pp. 353-361). Amsterdam: Elsevier/North-Holland.

Nicki, R., & Gale, A. (1977). EEG, measures of complexity, and preference for nonrepresentational works of art. *Perception*, **6**, 281-286.

Sargent-Pollock, D., & Konečni, V. (1977). Evaluative and skin-conductance responses to Renaissance and 20th century paintings. *Behavior Research Methods & Instrumentation*, **9**, 291-296.

Wohlwill, J. (1968). Amount of stimulus exploration and preference as differential functions of stimulus complexity. *Perception & Psychophysics*, **4**, 307-312.

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