THE INFLUENCE OF DESIGN SYMMETRY AND CONTOUR ON EYE FIXATIONS AND JUDGMENTS OF PERCEIVED COMPLEXITY, INTERESTINGNESS AND PLEASINGNESS

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ABSTRACT

THE INFLUENCE OF DESIGN SYMMETRY AND CONTOUR ON EYE FIXATIONS AND JUDGMENTS OF PERCEIVED COMPLEXITY, INTERESTINGNESS AND PLEASINGNESS

By

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This experiment studied the effect of two design complexity variables on eye fixations and judgments of complexity, interestingness and pleasingness. The two complexity variables were (1) number of contour angles in the figures included in the design, and (2) symmetrical versus asymmetrical arrangements of the figures in the designs.

A set of four designs were prepared manipulating the two complexity variables: (1) symmetrical design with figures having less angles, (2) symmetrical design with figures having more angles, (3) asymmetrical design with figures having less angles, and (4) asymmetrical designs with figures having more angles. Six sets of the four design manipulations were prepared using different figures for each set.

Each design consisted of two or three geometrical figures plus three-letter groups consisting of all

consonants or all vowels. The figures and letter groups were arranged either symmetrically or asymmetrically along a vertical axis. Because of the requirement of symmetry, the letters used were symmetrical (H, M, T, V, W, X, Y, A, and I). The same letter groups were used for all four designs in a set. Although no meaning was intended in either the figures or letters, the letter groups were used to make the designs more interesting for subjects. It was hoped that the designs would suggest more meaningful graphics such as posters, package labels or advertisements.

For the first phase of the experiment each of the 24 subjects (eight men and sixteen women recruited from classes at Michigan State University) viewed the six sets of designs using a Polymetric Eye Movement Recorder, Model V-1164-1. All four designs of a set were presented at the same time for ten seconds and the subject looked at whatever designs he wished. The eye fixations were recorded by a Pathe 16 mm. camera operating at eight frames per second.

During the second phase of the experiment, the subjects rated each design in the six sets in terms of complexity, interestingness and pleasingness. These variables were measured in terms of a seven-point scale with either "simple-complex," "interesting-uninteresting" or "pleasing-displeasing" as anchors.

Based on Daniel Berlyne's conceptualization of the attention process and his research findings, nine hypotheses were tested. Designs with more contour angles were expected to receive more eye fixations, and be judged more complex and interesting than designs with less angles. These three hypotheses were confirmed. It was predicted that symmetrical designs would receive less eye fixations, and be judged less complex and less interesting than asymmetrical designs. It was also predicted that eye fixations would cluster on one side of symmetrical designs, but would spread fairly evenly over asymmetrical designs. None of these hypotheses received any support. Similarly, two hypotheses predicting that designs with a lesser number of contour angles and symmetrical arrangements would be rated more pleasing, were not confirmed.

The analysis also indicated that the six sets of designs were differentiated in their perceived complexity and interestingness. There was a tendency for design sets with more contour angles to be judged more complex ($r = .69$) and more interesting ($r = .62$).

A number of possible explanations for the results were discussed, and it was suggested that perhaps symmetry operates differently than other visual complexity variables such as contour change. A number of possibilities for future research were also mentioned.

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By

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CHAPTER I

ATTENTION AND COMMUNICATION

Man has always been interested in being able to draw the attention of his fellow men, and to do this he has tried to "catch the eye." The eye, as perhaps the most important link between man and the physical world, has traditionally been considered the outward indicator of attention. Historically this is evident in the concern of the great Renaissance schools of art with techniques of picture design to insure that the eye followed the desired course through the composition.[1] Parallel to this tradition is the concern of the advertiser with the layout and design of a display advertisement to make the audience attend to his product. Similarly educators are concerned with visual communication techniques to increase their students' attention span and thus increase learning.

In the study of communication the process of attention is given much lip service. We are frequently concerned with the effects of messages on receivers in terms of attitude change, comprehension, information gain, decision making and so forth--all with the assumption that

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[1] R. Arnheim, Art and Visual Perception (Berkeley: University of California Press, 1954).

the receiver attends to the message. But before a message can have an effect, the receiver must admit it into his system. Gaining admittance is the first barrier a message must surmount in its attempt to affect behavior. Any given message must compete with a multitude of other messages, and with the physiological, cognitive and emotional state of the receiver as well. How to increase the probability that a person will attend to a given message in a multi-message situation, or a given element within a message, is central to understanding communication.

The impetus for this study began with an interest in the attention process and an interest in non-verbal communication--especially pictorial communication. What is it in a picture that catches the eye? Why does a person look at one picture longer than another? Why does he like one more than another? Such questions are basic to understanding pictorial communication, yet very little is known about this area. However, the work of one researcher, D. E. Berlyne, offers a beginning for an attack on this question. The intent of this paper is to follow up some of Berlyne's work and examine variables which affect a person's attention in terms of his looking behavior and in relation to judgments of interest and aesthetic value of a picture.

Of all the contemporary researchers in this area, perhaps Berlyne has developed the most detailed formulation of the attention process. He has synthesized a voluminous amount of research and related it to the more recent findings dealing with the orientation reaction. The result is a tentative theory of attention, more specifically, a theory of arousal, which he has presented in his book Conflict, Arousal and Curiosity[2] and in many journal articles.

Before continuing, it should be noted that research in this area, including Berlyne's work, is still exploratory and basic. There is a problem in trying to apply this work to communication--much of the research consists of psychophysical experimentation with restricted, non-meaningful stimuli as used in the traditional studies of perceptual phenomena. Extrapolation from this type of research to hypotheses about complex, interdependent, meaning-laden stimulus patterns such as a typical photograph, painting or drawing does not provide one with any sure-fire hypotheses. Indeed, the problem of making an inferential leap from complexity as defined by a neurophysiologist studying cats with parts of their brain removed, to complexity in a photograph with complete and healthy humans is rather deflating. Yet researchers such

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[2] D. E. Berlyne, Conflict, Arousal and Curiosity (New York: McGraw-Hill, 1960).

as Berlyne who are concerned with attention have made some significant, consistent findings, and have developed elaborate theoretic formulations about the process of attention. Berlyne is still a very long way from any complete theory, but he does provide a body of research and hypotheses to dip into.

Berlyne's Conceptualization of Stimulus Complexity

One of the variables Berlyne has been dealing with is that of stimulus complexity. Generally speaking, he suggests that complexity be considered the degree of differences of elements within a stimulus pattern. A stimulus pattern becomes more complex with an increase in the perceived number of elements in a pattern, with greater perceived differences among the elements and with less perceived grouping of the elements. The perception aspect is emphasized since the amount of complexity really depends on the number of experiential properties in the stimulus pattern, rather than the physical properties. However, the physical properties of a given pattern are the same for all individuals. The experiential properties vary from individual to individual, but one would expect some correlation with the physical.

According to Berlyne, complex stimuli are alike in increasing the level of conflict within an organism. When two or more sets of responses are aroused at the same time, the organism is faced with the problem of which is the "correct" response to produce. Both sets of responses are based on prior discrimination learning and have been reinforced by stimuli with certain characteristics. Moreover, if stimulus A evokes the expectation of stimulus B, but if instead of B, stimulus C occurs, two responses are aroused: one aroused by B and one aroused by C. If these latter two contrast, conflict between the expected and the actual responses takes place. Thus, in a complex pattern if one part of the pattern provides an expectation of what the rest of the pattern is like, the other elements physically present will disappoint the expectation, and so, conflict.

The amount of conflict produced increases with the number of aroused response tendencies that are in competition. Conflict is greater, the closer these responses are to being equal in strength, and the stronger the absolute strengths of the responses. With regard to the strength of the response tendencies, it is assumed that there is some threshold level that a response must reach before it contributes to conflict. It should be noted that a new response which is very strong relative to the conflicting responses will swamp that conflict, that is, the conflict will be reduced to a negligible amount.

Berlyne stresses that conflict is not a distinct condition that the individual is either in or not in. We would expect an organism to be constantly confronted with an environment which produces incompatible response tendencies, at least while in a waking state. The significant aspect of conflict is its amount, which varies constantly. Under "normal" circumstances, we would expect it to be moderate, yet there are times when it is unbearably intense. We are concerned here with stimulus conditions which tend to increase conflict only to moderate degrees as is the case, Berlyne suggests, in art and humor which are dependent upon conflict to produce their effects. That is, fluctuation in the level of conflict can be a very pleasurable experience.

Uncertainty and Expectations About Stimulus Patterns

In addition to conflict, an equally important characteristic underlying Berlyne's ideas is uncertainty. In information theory uncertainty is said to increase as the range of values a variable may take increases, and maximum uncertainty exists when a variable has an equal probability of taking a given value or not. In this sense we are looking at the information system--input, channel, output, and signal--from a god-like position, and the probabilities of the alternatives are objective probabilities. Uncertainty as discussed by Berlyne is from the receiver point of view, rather than the god-like figure above the system. Therefore, the term "uncertainty" as used here is "subjective uncertainty" which is a function of subjective probabilities, and is analogous to the objective uncertainty of information theory. The importance of this distinction is that uncertainty is defined from the individual's point of view.

While receiving stimuli, an organism is assumed to have expectations corresponding to the most probable or likely stimuli to come in the immediate future. The strength of these expectations increases with an increase in the probabilities of the future stimuli to which the expectations refer. Hence, incoming stimuli that have a low probability--high information--will be in conflict with the expectations. In this situation the organism's uncertainty is increased, as is the amount of conflict.

One can look at the relationship between uncertainty and conflict from a different viewpoint. When incompatible responses are called forth within the individual by discrepant items of information from a stimulus pattern, the individual is in a state of uncertainty about which response to perform. These responses are suspended or held in abeyance due to this uncertainty, and the individual will tend to seek more information to reduce his uncertainty. Complex stimuli produce uncertainty about how a pattern should be categorized--what overt response would be performed or what response label should be attached to the stimuli. When one portion of a complex pattern is perceived, there is increased uncertainty as to what will be perceived next.

Once conflicting response tendencies are produced within the individual, arousal is said to occur. The level of arousal correlates with the amount of conflict and is an index of how alert, mobilized or wide-awake the individual is. Berlyne compares the concept of arousal with that of drive in that both concepts are associated with energizing effects. But he points out that there is some optimal level of arousal at a given time, and that fluctuations in this level may be drive producing or aversive. The organism tries to keep the level of arousal at some optimal level. When arousal reaches this level, due to a complex pattern for example, exploratory behavior is likely to take place.

Exploratory Behavior and Perceptual Curiosity

Exploratory behavior allows the individual to gain more information about the situation by intensification of the stimulus pattern or by obtaining information from a new stimulus pattern. Berlyne discusses three types of exploration. The organism can change the direction of the sense organs, such as the eyes, toward the stimulus pattern or part of the pattern. He refers to this as an orienting response. The organism can also change the position of the whole body by movement--a locomotor response. A third type of exploratory behavior, investigatory responses, refers to manipulation of the stimulus by the individual, such as picking up an object and examining it, or re-exposing a tachistoscopically presented figure.

Berlyne suggests two general motivations for exploration. He sees diversive exploration as being a relief from boredom: the individual seeks stimulation from a wide range of sources for entertainment and pleasure. Specific exploration is the intensification of stimulation from a particular source. The individual needs more information to reduce his arousal and solve the dilemma of the conflicting response tendencies. Berlyne refers to this kind of reduction of arousal level through specific exploration as perceptual curiosity. He explains this term through the analogy of hunger and thirst drives which are reduced by consummatory behavior. Specific exploratory behavior brought on by perceptual curiosity is much like consummatory behavior in that it serves to lower the level of arousal.

The foregoing is a scanty outline of Berlyne's work, but it suggests that the relationship between complexity and attention is curvilinear. If a stimulus pattern is not complex enough, it will not be attended to; and similarly, if the pattern is too complex, the individual will tend to avoid it, fear it or "tune out." Therefore, there is some optimal range which will draw attention.

Review of Past Research

A review of the literature shows a number of studies, in addition to Berlyne's experiments, dealing with the relationship between complexity and attention. In studying infants, Fantz[3] has found that they tended to look at more complex shapes than at simple shapes, as measured by an observor. For example, infants spent the most time looking at a bullseye and a checkerboard design. Hershenson,[4] however, obtained conflicting results in studying newborn infants. He presented the infants with pairs of stimuli consisting of three black and white checkerboard patterns made up of 4, 16, and 144 squares. The infants looked more frequently at the pattern with four squares, and the author concluded that the infant preferred the least complex stimuli. However, Hershenson, Munsinger, and Kessen[5] found that newborn infants showed a preference for shapes of an intermediate variability. The infants looked more frequently at a geometric figure with 10 contour turns

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[3] R. Fantz, "The Origin of Form Perception," Scientific American, Vol. 204 (1961), 66-72.

[4] J. Kagan and B. Henker, "Developmental Psychology," Annual Review of Psychology, ed. by P. Farnsworth, O. McNemar, and Q. McNemar, XVII (Palo Alto: Annual Reviews, Inc., 1966).

[5] Ibid.

rather than figures with 5 or 20 turns. The authors suggest that although they controlled for the total black-white area ratio, there may be an "optimal length of black-white contour line" that attracts the infants. But a question has been raised as to the use of paired comparisons with infants since Watson reports that the side to which an infant orients on a particular trial is influenced by the side he looked at longest on the previous trial.[6]

Berlyne[7] presented children with a series of patterns which were varied in the amount of contour, such as a rectangle which was half black and half white, one in which the two diagonal quadrants were black, a checkerboard pattern, and a random black dot pattern. He then observed which pattern received the first fixation. Two patterns, a random black dot pattern and the checkerboard pattern were more likely than others to receive the first fixations. Since these two patterns had the most contour, Berlyne hypothesizes that scanning the pattern produces excitation of the cells within the eye that respond either to the onset or the termination of illumination. With the highly contoured designs, the scanning produces

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[6] Ibid.

[7] D. E. Berlyne, "The Influence of the Albedo and Complexity of Stimuli on Visual Fixation in the Human Infant," British Journal of Psychology, Vol. 49 (1958), 315-318.

more of the on-off excitation, and this might account for the high eye-drawing power of the patterns.

The relationship between complexity and looking behavior has also been studied by Cantor, Cantor, and Ditrichs.[8] Sixty children received six stimulus triads consisting of geometrically patterned figures considered by the authors to be of high, medium or low complexity. Each triad was presented for 60 seconds, and the children could look at any member of the triad for as long as they wished. The authors found that the children looked longer at the figures which were considered to be of high complexity. There was no difference between the medium and low complexity figures.

Using photographs of real objects and scenes which were rated on a seven point simple-complex scale by judges, Leckart studied the effects of stimulus complexity on looking time.[9] On the basis of the scales, he divided the pictures into three levels of complexity--high, medium and low. The results of the experiment, in which the subject could look at a picture for as long as he wished, showed a positive relationship between the level of

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[8] G. Cantor, J. Cantor, and R. Ditrichs, "Observing Behavior in Preschool Children as a Function of Stimulus Complexity," Child Development, Vol. 34 (1963), 683-689.

[9] B. Leckart, "Looking Time: The Effects of Stimulus Complexity, Stimulus Familiarity, and the Familiarization-Exploration Interval" (Unpublished Ph.D. dissertation, Michigan State University, 1965).

complexity and the amount of looking time for the photographs used.

In a study of perceptual curiosity, Berlyne presented subjects with tachistoscopic exposures of visual figures.[10] By pressing a key, the subjects could have as many exposures of each figure as they wished. Each exposure lasted .14 seconds. As previously noted, the analogy of hunger and thirst drives, commonly measured by the amount of consummatory behavior, can be likened to the exposure response that, like eating, leads to a reduction of the energizing effect of the drive. Thus the number of exposures to a figure is an indicator of the intensity of the drive aroused by that figure. With five series of pictures varied on the concepts of incongruity, meaningful sequence, surprise, relative entropy, and absolute entropy, he found that elements in the series which were incongruous, surprising, or which had the highest entropy or uncertainty received more responses than the other members in the series, and thus stimulated more curiosity.

Replicating Berlyne's experiment on perceptual curiosity, Minton obtained the same results, all

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[10]D. E. Berlyne, "Conflict and Information-Theory Variables as Determinants of Human Perceptual Curiosity," Journal of Experimental Psychology, Vol. 53 (1957), 399-404.

significant at the .001 level.[11] Moreover, he found that intercorrelations among the response categories across the variables were high, with the majority above .70, which indicates that all the figures tapped a common factor. Minton suggests this factor is probably best described as stimulus complexity.

Berlyne also studied the relationship between complexity and visual orientation.[12] He presented pairs of figures which differed in complexity in terms of irregularity of arrangement, amount of material, heterogeneity of elements, irregularity of shape, incongruity, and incongruous juxtaposition. An observer noted at which figure the subject looked first and how long he looked at it. For each pair of pictures, significantly more time was spent looking at the more complex figure. However, he found that the figure which was fixated first bore no consistent relation to the complexity variables.

In the above experiment, the stimulus figures were exposed for 10 seconds each. In order to control for the possibility that the more complex figures might take longer to identify, Berlyne[13] replicated the

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[11] H. Minton, "A Replication of Perceptual Curiosity as a Function of Stimulus Complexity," Journal of Experimental Psychology, Vol. 63 (1963), 522-524.

[12] D. E. Berlyne, "The Influence of Complexity and Novelty in Visual Figures on Orienting Responses," Journal of Experimental Psychology, Vol. 55 (1958), 289-296.

[13] D. E. Berlyne, "Supplementary Report: Complexity and Orienting Responses with Longer Exposures," Journal of Experimental Psychology, Vol. 56 (1958), 183.

experiment giving the subjects two minutes per exposure. If the subjects were given more time, the problem of identification would be controlled, and the subjects could view the figures "for the pleasure of looking." He found essentially the same results as in the earlier experiment: the subjects looked significantly longer at the more complex figures.

A comparison between the perceptual curiosity experiment and the visual orientation experiment is important from the viewpoint of Berlyne's theory. In the former experiment, the subjects received one figure at a time so that there was no competition between stimuli for attention. Past research indicates that reaction time to a stimulus increases with information theory measures such as the amount of information in the stimulus and the initial entropy level. This has been interpreted to mean that the human organism is a communication channel with a limited capacity, and therefore, more time is required to absorb more information. Because of this, one might assume that in a situation in which one stimulus is presented at a time, as in the curiosity experiment, the number of responses might be due to the amount of time necessary for the individual to absorb the information.

In the visual orientation experiment two stimuli were presented at a time, allowing the subject to choose between them. The findings in this study illustrate a different point than the suggestion that the responses in the curiosity experiment were based on the limited rate of taking in information. It seems that human beings tend to fixate on an aspect of the environment which is "relatively rich in information in preference to one that is poor."[14]

The results of these two experiments show that some of the variables that influence perceptual curiosity also influence visual orientation. This lends support to Berlyne's position that, to some extent, attention depends upon the curiosity arousing properties of the stimulus pattern. It seems likely that the more complex stimulus attracts more attention because the incomplete perception of them arouses a drive which is reduced by examination.

All of Berlyne's experiments described above use the same pairs of less complex and more complex stimulus patterns: irregularity of arrangement, amount of material, heterogeneity of elements, irregularity of shape, incongruity and incongruous juxtaposition. In order to control for the possibility that the stimulus figures used might have been too simple, he studied the effect of figures which have a higher level of complexity. The three new pairs of high complexity figures varied in: (a) the number of independent units in the pattern, in which the

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[14]D. E. Berlyne, "The Influence of Complexity and Novelty in Visual Figures . . . ," op. cit.

more complex of two patterns have a greater number of independent parts; (b) symmetrical versus asymmetrical patterns; and (c) random redistribution, in which the more complex of the pair of designs is a random redistribution of segments of the original design.

In a study of perceptual curiosity by Berlyne and Lawrence,[15] they found that for five of the six pairs of lower complexity designs, the more irregular (more complex) design was looked at longer in terms of a button pushing task in which the individual exposed each design one at a time for as long as he wanted. However, with the three pairs of more complex designs, only the random redistribution pair made a difference. Neither the asymmetrical design, or the design with the greater number of independent units, received significantly more exposure time. In another study by Berlyne and Lewis[16] with subjects in heightened arousal states, all of the more complex designs received significantly more exposure time, with the exception of the random redistribution design.

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[15] D. E. Berlyne and G. Lawrence, "Effects of Complexity and Incongruity Variables on GSR, Investigatory Behavior and Verbally Expressed Preference," Journal of General Psychology, Vol. 71 (1964), 21-45.

[16] D. E. Berlyne and J. Lewis, "Effects of Heightened Arousal on Human Exploratory Behavior," Canadian Journal of Psychology, Vol. 17 (1963), 398-411.

Design Variables: Symmetry and Contour Angles

In the literature reviewed above, many structural variables have been lumped under the heading of complexity and there has been no systematic study of these variables in relation to one another. In his work Berlyne has studied complexity variables such as: irregularity of arrangement of a pattern, amount of material, heterogeneity of elements and incongruity, among others. Attneave, in a study of judgments of complexity of 72 shapes found that "about 90% of the variance of ratings was explained by (a) the number of independent turns (angles or curves) in the contour, (b) symmetry and (c) the arithemetic mean of algebraic differences, in degrees, between successive turns in the contour."[17] The contour variables, alone, accounted for 78.7% of the variance explained. For the present study two complexity variables (a) number of angles in the pattern contours, and (b) symmetry are systematically manipulated in stimulus patterns.

Hypotheses about Eye Fixations

Rather than measuring attention in terms of amount of exposure to a single design as in Berlyne's perceptual curiosity experiments, or by gross measures of gaze

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[17]F. Attneave, "Physical Determinants of the Judged Complexity of Shapes," Journal of Experimental Psychology, Vol. 53 (1957), 221-227.

direction as in his work on eye orientation, the dependent variable is eye fixation as measured by an eye movement recorder. With an eye movement recorder, a much more precise measure of looking behavior is possible. In a multi-design presentation, the eye movement recorder has the advantage of measuring fixations both among and within designs.

Based on the above discussion, the following hypotheses are made.

H_1: Designs with elements having a greater number of angles in their contours will receive more eye fixations than designs with elements having a lesser number of contour turns.

H_2: Vertically asymmetrical designs will receive more eye fixations than vertically symmetrical designs.

In other words if four designs are presented which vary on a vertically symmetrical-asymmetrical dimension and two levels of "number of contour angles in the design elements," the design which has the greater number of contour angles and is asymmetrically arranged will receive the most fixations; the design that has the least number of contour angles and is symmetrical will receive the least number of fixations.

Attneave has demonstrated that symmetrical shapes are more redundant than asymmetrical shapes and therefore bring about less uncertainty.[18] Since, in vertically symmetrical designs, one half is the mirror image of the other, the eye can gain the information about the pattern from one side, and in a few glances confirm the redundancy of the other side. But in an asymmetrical design the eye must scan the whole design because the redundancy of arrangement is missing. This suggests a third hypothesis:

> H_3: In symmetrical designs most of the fixations will be clustered on one side of the vertical axis; whereas in asymmetrical designs the fixations will not be clustered but spread fairly evenly on both sides of the axis.

Hypotheses about Judgments of Perceived Complexity

While the preceding hypotheses deal with eye fixations, the rest of the hypotheses deal with the effect of the design variables on peoples' judgments. This study concerns two dimensions of complexity and assumes that complexity is an inherent property of the stimulus. But as Berlyne points out, perceived complexity and physical complexity in terms of design elements are not necessarily the same. He says that complexity "depends partly on physical properties that will be the same for all normal subjects and partly on habit structures that will vary from subject to subject."[19] To investigate the relationship

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[18] F. Attneave, "Some Informational Aspects of Visual Perception," Psychological Review, Vol. 63 (1954), 183-193.

[19] D. E. Berlyne, Conflict, Arousal and Curiosity, op. cit., p. 102.

between the two dimensions of complexity as physically manipulated and as perceived, the fourth and fifth hypotheses are:

> H_4: Design elements with more contour angles will be judged more complex than design elements with less contour angles.
>
> H_5: Asymmetrical designs will be judged more complex than symmetrical designs.

Thus of the four designs, the asymmetrical one with more angles will be judged the most complex; the symmetrical design with the lesser number of angles will be judged the least complex.

Hypotheses about Judgments of Interestingness and Pleasingness

The last four hypotheses concern the effect of the two dimensions of complexity on a person's judgment of how interesting and how pleasing the designs are. Berlyne investigated the relationship between complexity and evaluative ratings by having sixteen subjects rate his patterns on a seven-point interestingness scale, and another sixteen subjects rate the patterns on a seven-point pleasingness scale. For both groups the patterns were presented on a screen for three seconds each at intervals of five seconds. Of his eight design categories tested, Berlyne found that in two categories the more complex of the designs received significantly greater mean interest ratings. In six of the categories he found that the less complex designs received significantly greater mean pleasingness ratings. Overall, the direction of the means indicated that the more complex designs were rated more interesting and the less complex designs were rated more pleasing.

Berlyne suggests that the interestingness ratings reflect the internal processes which are related to the arousal properties of the stimuli. He says that "judgments of interestingness may therefore represent something like the amount of arousal increase that is promptly cancelled by inspection of a pattern. Judgments of pleasingness seem, on the other hand, to reflect internal processes dependent on arousal-reducing or arousal-restraining stimulus properties."[20]

Thus is seems that the interest ratings reflect the processes which are operative in the organism's perceptual curiosity state. Arousal is due to increased uncertainty about the stimuli, and is reduced to threshold level by exposure to the stimuli. On the other hand, the pleasingness ratings seem to reflect processes quite different than those of perceptual curiosity. It seems that stimulus deprivation plays a part in these circumstances.

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[20] D. E. Berlyne, "Complexity and Incongruity Variables as Determinants of Exploratory Choice and Evaluative Ratings," Canadian Journal of Psychology, Vol. 17 (1963), 274-290.

Two studies lend some support to Berlyne's ideas. Eisenman varied the number of angles in nine polygons and had subjects rate the figures on interest and pleasingness.[21] While there were no differences in the pleasingness ratings, he found that figures with more angles were rated as more interesting. More support for Berlyne was found in a study by Day.[22] Like Eisenman, the experimental figures consisted of polygons varying in number of angles which were rated on interest and pleasingness scales. Generally he found "pleasingness appears to be high for low levels of complexity but low at extremely high levels of complexity. Interest seems to increase with complexity to a peak and to remain fairly high with additional complexity."

The following hypotheses are made concerning design interest and pleasingness. With ratings of interest as the dependent measure, it is hypothesized that:

> H_6: Designs with elements having a greater number of contour angles will be rated more interesting than designs with elements having a lesser number of contour turns.

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[21] R. Eisenman, "Pleasing and Interest Visual Complexity: Support for Berlyne," Perceptual and Motor Skills, Vol. 23 (1966), 1167-1170.

[22] H. Day, "Evaluations of Subjective Complexity, Pleasingness and Interestingness for a Series of Random Polygons Varying in Complexity," Perception and Psychophysics, Vol. 2 (1967), 281-286.

H_7: Vertically asymmetrical designs will be rated more interesting than symmetrical designs.

With ratings of pleasingness as the dependent measure, it is expected that:

H_8: Designs with elements having a lesser number of contour angles will be rated as more pleasing than designs with elements having a greater number of contour turns.

H_9: Vertically symmetrical designs will be rated more pleasing than asymmetrical designs.

Thus of the four designs possible from the combination of the independent variables, the asymmetrical design having the greatest number of contour angles is expected to be judged the most interesting; while the symmetrical design with the least number of contour angles is expected to be judged the most pleasing.

CHAPTER II

THE EXPERIMENT

The experimental situation of the present study differs in three ways from the studies reviewed. First, the use of the eye movement recorder allows for a much more accurate and detailed investigation of visual looking behavior. Because of its capacity to detect small eye movements, the eye camera permits the testing of the hypothesis dealing with the dispersion of fixations in symmetrically arranged versus asymmetrically arranged designs. A second difference is also related to the eye camera. The earlier studies were limited to using single exposures with length of viewing time as the dependent measure, or paired comparisons with two stimuli presented at a time. In this study, because of the advantage of the eye camera, four stimuli are presented at a time allowing more alternatives for the subjects to select from and thus more competition among the designs. Finally, the previous studies varied one design variable at a time, as in Berlyne's work, but in this study one of the goals is to explore any relationship between the two variables, using the same elements in manipulating the independent variables.

Overall Procedure

The experiment was performed in a laboratory setting. The subject entered the room, was acquainted with the eye movement recorder and fitted to the device. The room was darkened except for the stimulus display area, and the subject was then shown six sets of designs, four designs to a set. Since the six design sets all tested the same hypotheses, the experiment was replicated six times for each subject. Each design set was presented for ten seconds and the subject looked at any or all of the four designs for as long as he wished during the time period.

After viewing the designs, the subject was given a packet of 24 cards with reproductions of each of the designs. The subject then went through the packet three times rating the designs on seven point scales for complexity, interestingness and pleasingness. The order of the three dependent judgment variables was systematically rotated. When the subject finished judging the designs, he filled out a personal information sheet and the experiment was explained to him. Each subject was asked not to reveal the study to anyone, and a check of each person upon first entering the laboratory indicated that none of the subjects knew about the experiment beyond the statement that it concerned "how people look at pictures."

This phrase was used by the experimenter as he went to various groups recruiting subjects.

Description of Subjects

Twenty-four subjects, eight men and sixteen women, were recruited from courses in the College of Communication Arts at Michigan State University. Because of the requirements of the eye movement recorder, the experimenter asked for volunteers who did not have astigmatism or eye muscle problems. Two of the subjects were replaced: upon being fitted to the apparatus, one subject was found to have astigmatism in the left eye and the other wore contact lenses. A description of the subjects is in Table 1.

Construction of Experimental Stimulus Designs

To test the hypotheses, six sets of designs (six replications of the experiment), were drawn varying the two dimensions of complexity. Each design consisted of two or three geometrical nonsense figures drawn with India ink on 3 5/8 inch square cards. A symmetrical design was defined as one with the figures arranged such that if a mirror were placed parallel with the vertical axis which bisected the square, the reflection would complete the design. In an asymmetrical design the reflection would not complete the design.

TABLE 1.--Description of Subjects: Age, Education, and Courses Used for Recruitment.

		Men	Women
Age	17 years	4	
	18 years		1
	19 years	2	3
	20 years		3
	21 years	1	3
	22 years	1	4
	23 years		1
	39 years		1
Mean Age		18.62	21.75
Number of Quarters in University			
	1 - 3	5	4
	4 - 6	1	1
	7 - 9		4
	10 -12	1	5
	13 or more	1	2
Courses from Which Subjects Were Recruited			
Introduction to Communication		5	5
Public Speaking I		3	7
The Effects of Communication			1
Persuasive Speaking			3

Complexity was also manipulated by varying the number of contour angles in a figure. This variable refers to the number of angles in the contour and intersections of lines in the figure--in other words all the coordinates of a design necessary for reproducing the figure. To prepare the two levels of complexity in terms of changes in contour, the figure with less number of angles was drawn on graph paper. Then another design was drawn such that the area of the figures and the spacial distances and relationships were the same--the only difference between the first and second designs was that the second had an increase in the number of contour angles and intersecting lines in the figures. (See Appendix A for illustrations of the designs used in each replication.) Below are listed the six sets of designs by name and number of contour angles in the figures in both the low and high complexity conditions.

TABLE 2.--Number of Contour Angles in High and Low Complexity Conditions for All Replications.

Name	Low Complexity	High Complexity	Total
TVT	3	6	9
WYW	4	12	16
YTY	5	13	18
AIA	6	14	20
MHM	10	22	32
HXH	12	49	61

The name of the design mentioned above refers to a three letter grouping that was included in each design, with the same letter combination used in all four designs in a set. Of the six sets of letters, five consisted of three consonants (TVT, WYW, YTY, MHM and HXH) and one of three vowels (AIA). The letters chosen were symmetrical on a vertical axis like the experimental figures. This was done so when the three letters were placed in the center of a design, as in HXH, a mirror placed parallel with the group on the vertical axis, at the intersection of the lines of the X, would reflect and complete the combination of letters.

The purpose of the letters was to provide added interest for the subjects in that they could look for a relationship between the figures and the letter combinations (although none was intended). Also, the same letters in each design of a set identified the design as belonging to that set. The letters were not chosen for their meaning; in fact, the goal was to avoid meaningful combinations. It was hoped that the combination of figures and letters would in some way simulate the pattern of forms and letters in posters, advertisements, packages and other graphic designs that we see daily. Yet it is obvious that the figures and letters used here are far removed from the pictures and scenes people encounter in their daily lives. This, of course, lowers the generalizability of the study; nevertheless, research at this time necessitates the use of content-free shapes tested in a laboratory setting. Such research will hopefully provide some knowledge of structure as a basis for prediction when working with more meaningful and familiar shapes.

Measurement of Eye Fixations

Eye fixations were measured by a Polymetric Eye Movement Camera, Model V-1164-1, with a Pathe 16 mm. reflex motion picture camera.[23] This recorder operates by reflecting a light off the cornea of the left eye into a camera and simultaneously reflecting the stimulus material into the camera through a series of lenses and prisms. The result is a film superimposing the two images so that eye fixation is indicated by a dot of light on the stimulus pattern. According to the manufacturers specifications, the recorder is accurate within plus or minus one-half degree.

There are a number of disadvantages to this recorder which are related to the artificiality of the experimental situation. First, the subject must be fitted to the apparatus. A bite stick covered with dental wax is used to insure that the subject's head does not move and

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[23]Norman H. Mackworth, "A Stand Camera for Line-of-Sight-Recording," Perception and Psychophysics, Vol. 2 (1967), 119-127.

is aligned after rest periods. A five minute familiarization period explaining the recorder and its functioning was necessary to help the subject feel more comfortable with the mysterious device, and to help him relax after asking him to bite into hot wax for the dental impression on the bite stick. Second, except for the stimulus area the room was dark during the experiment. And finally, much of the time with each subject was spent calibrating the stimulus and eye fixation images. Through practice the experimenter was able to adjust the lens system to the subject in about five minutes, but because subjects are easily fatigued by this kind of task, frequent rest periods were required after which the subjects had to be recalibrated. These rest periods were necessary; otherwise, the eye would produce tears and cause a blurred image of the light reflected off the corneal surface. However, because of the bite stick and the dental impressions, these recalibrations averaged only about thirty seconds. While these disadvantages are bothersome and certainly do not provide a very realistic viewing situation, the recorder does permit an accurate measurement of eye fixation.

Each set of four designs was presented on a black background board in a two by two arrangement--a design in each quadrant separated by a black band one-half inch wide. The four designs, including the separation strips, filled a 7 3/4 inch square space on the stimulus boards, which were twenty-eight inches from the subject's eyes.

The six stimulus boards were made so that the designs could be moved from one quadrant to another. In order to account for the effect of the design position, the designs were rotated for each subject and each of the six replications. The method used was to list the twenty-four possible permutations of the four positions of the designs, and then to systematically rotate each permutation so that each arrangement of the four designs was used six times throughout the entire experiment. Likewise, to account for possible effects of the order of presenting the six replications, each set of designs was randomly ordered for each subject.

Eye fixation was measured by counting frames of film. The recording camera was operated at a speed of eight frames per second and each replication or set of designs was exposed for ten seconds. Thus, eye fixations were indicated by the percentage of 80 frames in which the spot of light was located in each design or quadrant of the stimulus board.

To test the hypotheses concerning the dispersion of fixations in symmetrically versus assymetrically arranged designs, each design was divided into two equal sections and an index of dispersion was developed: the absolute value of the number of frames with the reflection spot in the left half of each design divided by the sum of the frames with the reflection spot in both the left and the right halves of the design, minus .50.

$$\left|\left(\frac{A}{A + B}\right) - .50\right|$$

A = number of frames with reflection spot in left half of design

B = number of frames with reflection spot in right half of design

The result was a score which could vary from 0 to .5, with higher scores representing more clustering of fixations on one side or the other of a design, and the lower score representing a fairly even distribution of fixations over the whole design.

After the subject was positioned to the recorder and fitted to the bite stick, the lights were turned off except for the stimulus stage and the light reflected off the subject's left eye. The subject was asked to look at targets while the reflected spot of light was located. Once the corneal reflection was calibrated such that the experimenter could predict the position of the eye fixations, the camera was run to familiarize the subject with its sound. The subject was then shown a sample set of four nonsense figures, and the procedure to be followed during the experiment was explained.

The experiment proper then began. The subject fixated on the centers of nine circles on a 7 3/4 inch square calibration card, with the camera operating. The experimenter asked him to "close your eyes, relax and sit very still." The calibration card was removed, the camera restarted, and the subject opened his eyes and looked at what he wanted to. At the end of ten seconds, he closed his eyes and the stimulus board was removed. When the subject opened his eyes again, he saw another calibration card and the same procedure was repeated. There were two rest periods, after the second set of designs and after the fourth. Throughout the experiment the subject was told to "relax," "be calm," to "sit very still," and to "hold your head very still." The same instructions were given to each subject. Appendix B is the sequence of events of this part of the experiment.

Measurement of Judgments of Perceived Complexity, Interestingness, and Pleasingness

After the recording of eye fixations was completed, the lights were turned on and the subject moved to the second part of the experiment--rating each of the designs on its perceived complexity, interestingness and pleasingness. All of the designs were reproduced in the same size as the originals in the first part of the experiment. Each of the four designs in the six sets of replications was mounted on a five by eight inch card and these 24 cards were bound together with two rings making a small flip chart. The loose-leaf flip chart allowed the designs to be randomly ordered for each subject.

A similar flip chart arrangement was made for the three dependent measures. A single seven-space rating scale with the center space boxed was printed on a five by eight inch sheet with either "Complex - Simple," "Interesting - Uninteresting," or "Pleasing - Displeasing" used as anchors. Thus, a set of 24 pages with one scale per page was stapled together for each measure. For each subject three packets of scales were prepared: one with 24 complexity scales, one with 24 interestingness scales, and one with 24 pleasingness scales.

The subject read a standard sheet of instructions on how to use a rating scale and was then given the flip chart with the 24 randomized pictures of the designs and a set of 24 scales of one of the three dependent measures. Since there are six possible ways of ordering complexity (C), interest (I) and pleasingness (P) scales--CIP, CPI, IPC, ICP, PIC, PCI--and 24 subjects, each of the possible orders was used four times throughout the entire experiment. The subject flipped one design card and one sheet of a set of scales, 24 times. Then he began again with the designs cards and another set of 24 scales, and this was repeated for the third dependent variable. This procedure permitted the subject to judge each design independently of the others and to ignore his previous scale markings.

Interpretation of Eye Fixation Measures and Statistical Design

The films of the eye fixations were coded by using a 16 mm. Kodak Analyst projector with a hand-crank that permitted frame-by-frame study. For each of the 24 subjects, a total of 60 seconds of film was analyzed (10 seconds for each of the six replications). Since the camera was operated at a speed of eight frames per second, there was a total of 480 frames analyzed for each subject in addition to noting the calibration tests run before each replication.

Two coders viewed the filmed records of all the subjects and noted jointly the location of the light spots on each frame which represented the corneal reflection. To check the accuracy of the coding, the 10 second record of one of the replications for each subject was randomly chosen and analyzed independently by a third coder. The third coder's scores for each of the 24 samples was correlated with the scores of those same records as originally coded. The correlation was high (.995) indicating an overall accuracy in the coding.

The data for the measure of eye fixation was subjected to a treatment by treatment by subject by replication analysis of variance design. This same statistical design was used to analyze the complexity, interestingness, and pleasingness scores.

CHAPTER III

FINDINGS

Overall, of the two complexity variables, only variation in the number of contour angles affected the dependent measures. There were no consistent findings regarding the effect of symmetry and thus none of the hypotheses concerning this variable received any support.

Design Complexity and Eye Fixation

There was support for the first hypothesis that designs having a greater number of contour angles would receive the greatest number of eye fixations. The overall mean number of fixations for designs with less angles was 22.06; whereas for the designs with more angles, the mean number of fixations was 27.94. This difference, shown in Table 3, was significant beyond the .01 level. Table 4 indicates that for each set of designs, the mean number of fixations was greater for designs having more contour angles.

Table 3 also indicates that symmetry and asymmetry did not make a difference in eye fixations, and thus the second hypothesis was not confirmed. The mean fixation

TABLE 3.--Analysis of Variance of Design Fixation Scores.

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Symmetrical-Asymmetrical	18.06	1	18.06	-
Error	7936.77	23	345.08	
Less-More Contour Angles	4982.01	1	4982.01	9.24*
Error	12401.83	23	539.21	
Design Replications	.03	5	.01	-
Error	.80	115	.01	
Sym.-Asym./Contour Angles	29.34	1	29.34	-
Error	2491.83	23	108.34	
Sym.-Asym./Replications	435.65	5	87.13	-
Error	15790.52	115	137.31	
Contour Angles/Replications	478.78	5	95.76	-
Error	12590.38	115	109.48	
Sym.-Asym./Contour Angles/Replications	550.45	5	110.09	-
Error	16139.38	115	140.34	
Subjects	.16	23	.01	-
Error	.00	0	.00	
		575		

*Significant beyond the .01 level.

TABLE 4.--Mean Fixation Scores for the Two Design Complexity Variables and the Six Replications.*

Name	Symmetrical Designs		Asymmetrical Designs		Total
	Less Contour Angles	More Contour Angles	Less Contour Angles	More Contour Angles	
TVT	20.46	28.13	22.08	29.33	25.00
WYW	21.58	31.17	21.17	26.08	25.00
YTY	20.63	26.58	21.29	31.50	25.00
AIA	20.95	28.00	24.87	26.25	25.00
MHM	22.00	28.58	22.88	26.54	25.00
HXH	24.33	25.50	22.50	27.67	25.00
TOTAL	21.66	27.99	22.47	27.90	

*Total sample size is 24, distributed equally over the 24 cells.

score for the symmetrical designs was 24.83 versus a mean score of 25.18 for the asymmetrical designs (see Table 4).

There was no support for the third hypothesis that fixations would be clustered on one side of a vertical axis of the symmetrical designs, but spread on both sides of the asymmetrical designs (see Table 5). The mean scores of the index of eye fixation dispersion described in Chapter II are shown in Table 6. The higher the index, the more clustering on one side of a design; the lower the index, the less clustering. As can be seen in Table 6, symmetry did not effect the clustering of eye fixations.

Design Complexity and Judgments of Perceived Complexity

The fourth hypothesis that designs with more contour angles would be judged as more "complex" on a seven-point scale was substantiated by the data. The results of testing this hypothesis shown in Table 7 indicate a significant interaction between the complexity variable (angles) and the six sets of design replications. An examination of the mean scores of the two complexity variables for each of the six replications explains the interaction (see Table 8). In each case the designs with more angles received a higher mean complexity score than designs with less angles. The significance of the interaction is that the difference between the mean complexity scores for designs with less angles and those with more

TABLE 5.--Analysis of Variance of Fixation Dispersion Index Scores.

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Symmetrical-Asymmetrical	68.06	1	68.06	-
Error	9037.35	23	392.93	
Less-More Contour Angles	261.36	1	261.36	-
Error	3228.22	23	140.36	
Design Replications	2271.95	5	454.39	-
Error	39587.47	115	344.24	
Sym.-Asym./Contour Angles	.44	1	.44	-
Error	3558.97	23	154.74	
Sym.-Asym./Replications	1736.65	5	347.33	-
Error	31039.94	115	269.91	
Contour Angles/Replications	1067.47	5	213.49	-
Error	19261.94	115	167.50	
Sym.-Asym./Contour Angles/Replications	1222.22	5	244.44	-
Error	19794.36	115	172.12	
Subjects	8635.41	23	375.45	-
Error	.00	0	.00	
		575		

TABLE 6.--Mean Fixation Dispersion Index Scores for the Two Design Complexity Variables and the Six Replications.*

Name	Symmetrical Designs		Asymmetrical Designs		Total
	Less Contour Angles	More Contour Angles	Less Contour Angles	More Contour Angles	
TVT	31.42	28.17	20.67	28.04	27.07
WYW	26.21	28.79	29.04	24.00	27.01
YTY	29.63	22.79	26.79	20.17	24.84
AIA	24.13	24.83	23.04	20.50	23.13
MHM	25.92	22.63	28.38	28.08	26.25
HXH	18.75	21.08	24.33	23.04	21.80
TOTAL	26.01	24.72	25.38	23.97	

*Total sample size is 24, distributed equally over the 24 cells.

TABLE 7.--Analysis of Variance of Design Complexity Scores.

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Symmetrical-Asymmetrical	.00	1	.00	-
Error	80.62	23	3.51	
Less-More Contour Angles	744.84	1	744.84	111.63*
Error	153.46	23	6.67	
Design Replications	499.82	5	99.96	30.77*
Error	373.64	115	3.25	
Sym.-Asym./Contour Angles	1.89	1	1.89	-
Error	24.57	23	1.07	
Sym.-Asym./Replications	2.40	5	.48	-
Error	98.22	115	.85	
Contour Angles/Replications	49.45	5	9.89	6.91*
Error	164.51	115	1.43	
Sym.-Asym./Contour Angles/Replications	3.06	5	.61	-
Error	90.73	115	.79	
Subjects	171.71	23	7.47	-
Error	.00	0	.00	
		575		

*Significant beyond the .01 level.

TABLE 8.--Mean Perceived Complexity Scores for the Two Design Complexity Variables and the Six Replications.*

Name	Symmetrical Designs		Asymmetrical Designs		Total
	Less Contour Angles	More Contour Angles	Less Contour Angles	More Contour Angles	
TVT	1.75	4.04	1.83	3.96	2.90
WYW	2.08	5.25	2.21	5.17	3.68
YTY	2.83	6.21	2.92	5.67	4.41
AIA	1.83	3.67	2.21	3.54	2.81
MHM	4.13	6.08	4.38	6.17	5.19
HXH	4.13	5.83	3.92	5.92	4.95
TOTAL	2.79	5.18	2.91	5.07	

*Total sample size is 24, distributed equally over the 24 cells.

is greater for some of the six replications than for others. This can be seen more clearly in Table 9. The difference between the mean complexity scores for more and less contour angles varies for each of the six sets of designs. For example, the difference between the two means for designs WYW and YTY is 3.06; whereas, the difference between the two means for design AIA is only 1.58. Separate analysis of variance tests for each of the six replications indicates that the differences between the mean scores for more and less angles was significant beyond the .01 level (see Table 9). Thus, the fourth hypothesis is supported.

The fifth hypothesis that asymmetrical designs would receive higher perceived complexity scores than symmetrical designs was not confirmed (see Table 7). The mean complexity score for both symmetrical and asymmetrical designs was 3.99.

Design Complexity and Judgments of Interest

The sixth and seventh hypotheses concern the effect of the two complexity variables on the subjects' "interest" ratings of the designs. The data supported the sixth hypothesis that the subjects would find designs with more changes in contour more interesting than designs with less contour change. Like the test results for the fourth hypothesis, the results of testing the sixth one in Table 10

TABLE 9.--Mean Perceived Complexity Scores for Less Versus More Number of Contour Angles and the Six Replications.

Name	Less Angles	More Angles	Difference
TVT	1.79	4.00	2.21*
WYW	2.15	5.21	3.06*
YTY	2.88	5.94	3.06*
AIA	2.02	3.60	1.58*
MHM	4.25	6.13	1.88*
HXH	4.02	5.88	1.86*
TOTAL	2.85	5.13	

*p is less than .01.

TABLE 10.--Analysis of Variance of Design Interestingness Scores.

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Symmetrical-Asymmetrical	.01	1	.01	-
Error	72.99	23	3.17	
Less-More Contour Angles	386.78	1	386.78	51.65*
Error	172.22	23	7.49	
Design Replications	322.85	5	64.57	18.64*
Error	398.31	115	3.46	
Sym.-Asym./Contour Angles	.17	1	.17	-
Error	14.49	23	.63	
Sym.-Asym./Replications	5.26	5	1.05	-
Error	113.24	115	.98	
Contour Angles/Replications	33.28	5	6.66	3.10*
Error	247.22	115	2.15	
Sym.-Asym./Contour Angles/Replications	4.47	5	.89	-
Error	103.36	115	.90	
Subjects	329.08	23	14.31	-
Error	.00	0	.00	
		575		

*Significant beyond the .01 level.

show a significant interaction between the contour variables and the six design replications. As can be seen in Table 11, the mean interest scores of the designs with more angles are greater than designs with less angles for each replication. As was the case in testing the fourth hypothesis, the reason for the significant interaction is that the difference between the mean interest scores for designs with more angles and designs with less angles is greater for some of the six replications than for others. Table 12 lists the mean interest scores for the contour variable for each design replication. The difference between the mean scores varies for each of the six sets of designs. The difference between the two means for design YTY, for example, is 2.27; but the difference is only .83 for design HXH.

A separate analysis of variance test was performed for each of the six replications. The difference between the means was significant beyond the .01 probability level for five of the six design sets. The difference of .83 between the means for design HXH was not large enough to be significant.

Symmetry-asymmetry did not affect interest ratings. The seventh hypothesis that asymmetrical designs would receive higher interest ratings than symmetrical designs was not substantiated (see Table 10). The mean interest rating for both symmetrical and asymmetrical designs was 4.48.

TABLE 11.--Mean Interestingness Scores for the Two Design Complexity Variables and the Six Replications.*

Name	Symmetrical Designs		Assymmetrical Designs		Total
	Less Contour Angles	More Contour Angles	Less Contour Angles	More Contour Angles	
TVT	2.75	4.50	3.00	4.25	3.63
WYW	3.54	5.63	3.17	5.42	4.44
YTY	3.42	5.67	3.71	6.00	4.70
AIA	2.79	4.13	2.50	4.42	3.46
MHM	4.71	6.25	4.96	6.29	5.55
HXH	4.83	5.50	4.54	5.54	5.10
TOTAL	3.67	5.28	3.65	5.32	

*Total sample size is 24, distributed equally over the 24 cells.

TABLE 12.--Mean Interestingness Scores for Less Versus More Number of Contour Angles and the Six Replications.

Name	Less Angles	More Angles	Difference
TVT	2.88	4.38	1.50*
WYW	3.35	5.52	2.17*
YTY	3.56	5.83	2.27*
AIA	2.65	4.27	1.62*
MHM	4.83	6.27	1.44*
HXH	4.69	5.52	.83
TOTAL	3.66	5.30	

*p is less than .01.

Design Complexity and Judgments of Pleasingness

The last two hypotheses dealt with the effect of the two complexity variables on the subjects' ratings of the pleasingness of the designs. The eighth hypothesis predicted that designs with less contour change would be rated more pleasing than designs with more contour change; the ninth hypothesis predicted that symmetrical designs would be judged more pleasing than asymmetrical designs. There was no support for these two hypotheses. Table 13 shows that the two complexity variables did not influence the pleasingness ratings. As can be seen in Table 14, there is no consistency in the mean scores. Designs with more angles had a mean pleasingness rating of 4.74, while designs with less angles had a mean rating of 4.45. Symmetrical designs had a mean of 4.65, while asymmetrical designs had a mean of 4.53. The significant replications factor in Table 13 does not affect the findings regarding the hypotheses under study.

Overall, then, hypotheses 1, 4 and 6 concerning the effect of variation in amount of contour on eye fixation, perceived complexity and interest ratings received support. Hypotheses 2, 3, 5, 7, 8 and 9 did not receive support.

TABLE 13.--Analysis of Variance of Design Pleasingness Scores.

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Symmetrical-Asymmetrical	1.89	1	1.89	-
Error	169.65	23	7.38	
Less-More Contour Angles	11.96	1	11.96	-
Error	312.08	23	13.57	
Design Replications	149.84	5	29.97	6.95*
Error	496.03	115	4.31	
Sym.-Asym./Contour Angles	.63	1	.63	-
Error	9.75	23	.42	
Sym.-Asym./Replications	1.62	5	.32	-
Error	107.59	115	.94	
Contour Angles/Replications	19.84	5	3.97	-
Error	310.87	115	2.70	
Sym.-Asym./Contour Angles/Replications	6.80	5	1.36	-
Error	78.57	115	.68	
Subjects	188.00	23	8.17	-
Error	.00	0	.00	
		575		

*Significant beyond the .01 level.

TABLE 14.--Mean Pleasingness Scores for the Two Design Complexity Variables and and the Six Replications.*

Name	Symmetrical Designs		Asymmetrical Designs		Total
	Less Contour Angles	More Contour Angles	Less Contour Angles	More Contour Angles	
TVT	3.92	4.13	4.17	3.96	4.04
WYW	4.17	4.17	3.96	3.92	4.05
YTY	4.67	5.54	4.88	5.29	5.09
AIA	3.92	4.46	4.00	4.25	4.16
MHM	4.71	5.75	4.67	5.33	5.11
HXH	5.46	4.92	4.88	5.13	5.09
TOTAL	4.47	4.83	4.42	4.65	

*Total sample size is 24, distributed equally over the 24 cells.

CHAPTER IV

DISCUSSION AND FUTURE IMPLICATIONS

Summary of the Study

This study was motivated by the question, "What is it in a picture that makes people attend to it?" Such a question is the core to the study of how a man relates to his environment. What a person attends to and how he attends is central to understanding him. Attention can be studied in terms of a person's physical and cognitive state, his personality, and his interests or preferences and their influence on his perception of the environment. Another approach is to explore the relationships among the elements of a man's environment and try to determine what relationships or structures are more likely to receive his attention. The present experiment studied two structural variables related to graphic designs and their effects on attention in a controlled visual environment.

There are many principles of design that may be categorized according to their capacity for increasing the attention to, interest in and aesthetic value for a picture, but very little research has been done along this line. One such design variable which has received some research consideration is complexity. Daniel Berlyne has performed a number of experiments dealing with complexity and related variables. Two dimensions of complexity were studied here, one dealing with variation in contour in terms of number of angles in a figure, and the other dealing with the symmetrical versus asymmetrical arrangement of the figures in a design. These variables were tested in light of their effect on eye fixations, and judgments of perceived complexity, interest and pleasingness of the designs.

The study of eye fixations required the use of an eye movement recorder. This device allows for a much more detailed analysis of what people look at in a picture than previous measures of looking behavior. Because it can detect small eye movements, a person's looking behavior can be analyzed not only for comparisons between designs, but also for what a person looks at within a design.

A major difference between this study and previous ones was made possible by the recorder. Berlyne has studied both symmetry-asymmetry and contour variation separately, but the goal of this study was to examine the interaction between the two design variables. Therefore, during the experiment the subject was placed in a multi-design situation in which four designs competed for his attention at the same time: symmetrical designs with less contour variation, symmetrical designs with more contour variation, asymmetrical designs with less contour variation and asymmetrical designs with more contour variation. Most earlier studies were limited to length of time as the dependent measure or comparisons between two stimuli presented at the same time, but the eye camera allows a study of the competition of the variables affecting attention.[24]

To study the two complexity variables, designs were prepared consisting of geometric figures and three letter vowel or consonant groupings. Complexity was manipulated by varying the number of contour angles in the figures and using symmetrical versus asymmetrical arrangements of the figures and letters. Thus four designs were prepared. Since the study was replicated six times for each of the 24 subjects, altogether six sets of four designs were used.

Based on Berlyne's conceptualization of the attention process and his research findings, nine hypotheses were tested. Designs with more contour angles were expected to receive more eye fixations, and be judged as more complex and interesting than designs with less angles. These three hypotheses were confirmed. It was also predicted that eye fixations would cluster on

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[24]B. Leckart and T. Faw, "Looking Time: A Bibliography," Perceptual and Motor Skills, Vol. 27 (1968), 91-95.

one side of symmetrical designs, but would be spread fairly evenly over asymmetrical designs. None of these hypotheses received any support. Similarly, two hypotheses concerning pleasingness of the designs were not confirmed. It was predicted that designs with a lesser number of contour angles and symmetrical arrangements would be rated more pleasing, but the data indicated no significant differences.

The Effect of Contour Variation

Designs with more contours were looked at more and judged as more complex and interesting. But there were significant interactions in the data for tests of the fourth hypothesis about contour and complexity and the sixth one about contour and interest. As explained in the third chapter these significant interactions were related to the replications. The difference between the effect of less and more contour variation on complexity judgments varied from replication to replication, but all the differences were in the predicted direction. Separate tests showed that the difference for each replication was significant. The same was true of the findings for contour and interest (although the separate analysis on the mean interest scores for replication HXH did not reach significance). Therefore, given that the interactions were due to the fact that some of the replications had more hypothesized differential effects than others, a question remains regarding why this occurred.

One way of examining the interaction is to look at the variation in contour not only between the two experimental manipulations (more and less contour angles) but also among the replications. In Table 2, Chapter II, the number of contour angles for the designs is listed and the replications are ordered in terms of their total number of angles. The effect of amount of variation among replications was not one of the hypotheses under study, but examining this effect might help explain the interaction. In this sense we are no longer considering the design sets as replications, but as treatments. If we list the designs by total number of contour angles (the "more angles" plus "less angles" treatments) and relate this index to the perceived complexity scores for each design, perhaps we can see some relations. Below is a list of each design with the total angles and the total complexity scores. The total complexity scores were obtained by summing the mean scores for each design in the "less angles" and the "more angles" treatments in Table 9.

In Figure 1 these scores have been plotted on a set of coordinates. The correlation between angles and complexity was .69. The correlation suggests a pattern: as the total number of angles increases, so do the total complexity judgment scores.

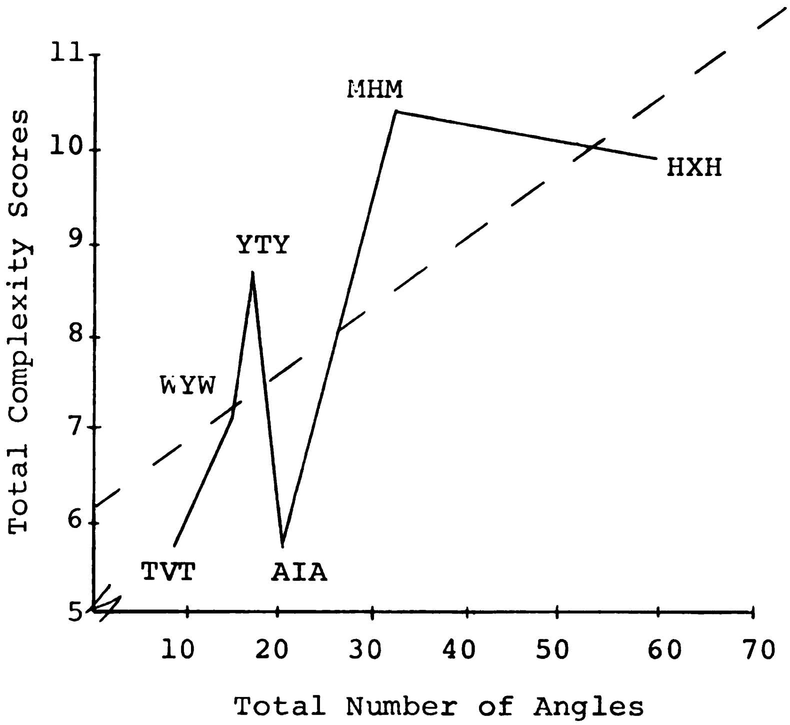

Figure 1.--Relation between Total Number of Angles and Total Mean Complexity Scores.

TABLE 15.--Relation between Total Number of Angles and Total Mean Complexity Scores.

Design	Angles	Complexity
TVT	9	5.79
WYW	16	7.36
YTY	18	8.82
AIA	20	5.62
MHM	32	10.38
HXH	61	9.90

The design which deviated the most from the general relationship was the AIA design, the only design consisting of vowels. It could be that the vowel grouping was seen as simpler than the consonant grouping. One possible explanation is that since there are less vowels than consonants in the written language, we encounter vowels more frequently and therefore they may be seen as more familiar and less complex. The consonant groupings might have been seen as more of a "puzzle" to interpret because consonants are typically used in abbreviations--the subjects might have seen the consonants as abbreviations.

Thus, the significant interaction between the effect of contour variation and the replications seems to be due primarily to the effect of the overall amount of contour variation from replication to replication. Except for the vowel grouping design, there was a tendency for the subjects to judge the more complex design sets (in terms of total number of angles) as being more complex.

The interaction between more and less contour variation and the replications in the findings for the hypothesis concerning interest ratings can be examined in the same manner as for the complexity interaction. Again, we are considering the replications as a treatment variable. Table 16 shows the summed number of contour angles for each replication (for the "more angles" and "less angles" treatment indicated in Table 2) and the total perceived complexity scores for each replication (the sum of the mean complexity scores in the "less angles" and the "more angles" treatments in Table 12).

TABLE 16.--Relation between Total Number of Angles and Total Mean Interest Scores.

Design	Angles	Interest
TVT	9	7.26
WYW	16	8.87
YTY	18	9.39
AIA	20	6.92
MHM	32	11.10
HXH	61	10.21

Plotting these scores on a set of coordinates we find the relationship is almost identical to the one found in the complexity interaction (r = .62). This correlation suggests that, as the total number of angles increases, so do the total mean interest judgment scores. As was the previous case, the largest exception was design AIA. (See Figure 2.)

The analysis of the two interactions indicates that not only did the amount of contour change effect the judgment of complexity and interest in the hypothesized direction, but that there was a tendency for design sets having more overall contour change to be judged more complex and more interesting. An exception to this trend in both the complexity and interest cases was design AIA, and this might be due to the letter grouping included in the design rather than the contour variation of the figures. Thus, more contour variation both within design sets and among sets seemed to be related to greater perceived complexity and greater interest.

Since complexity and interestingness ratings were both related to the number of contour angles within and among design sets, it could be that both measures were tapping the same concept. To check this possibility, the two measures were correlated and the coefficient, r = .50, suggests that while complexity and interestingness ratings are related, they are surely not the same thing. Correlation coefficients were also obtained for complexity and

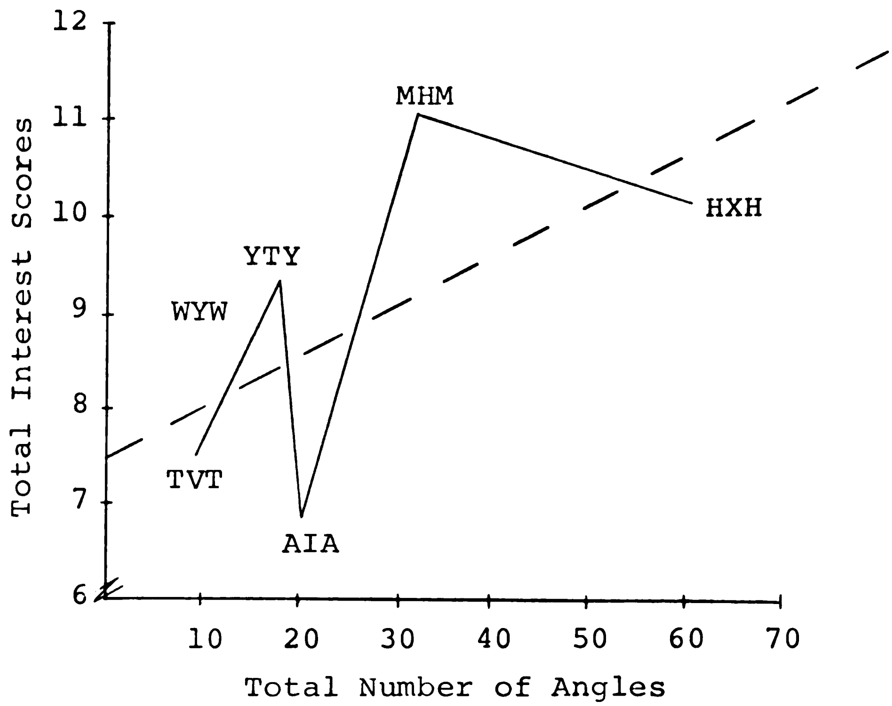

Figure 2.--Relation between Total Number of Angles and Total Mean Interest Scores.

pleasingness ratings (r = .19), and interestingness and pleasingness ratings (r = .47). It seems that interestingness and pleasingness are related almost as much as complexity and interestingness.

The Effect of Symmetry

None of the hypotheses concerning symmetry was supported. In trying to determine the complete lack of confirmation a number of rationales can be suggested. Although there is no indication that a longer viewing time would have made a difference, perhaps ten-second exposures are not enough. Berlyne used this amount of time in a number of his studies with two stimuli presented at a time. Here four designs were presented together and perhaps more time is necessary to see patterns of fixations. Since the contour variable did make a difference, a person may need more time to notice the difference between symmetrical and asymmetrical designs.

The idea that eye fixations would cluster on one side of symmetrical designs but would be spread throughout asymmetrical designs was not substantiated. Perhaps, here too, more time would have made a difference, although a more likely reason might be that a person does not look at pictures in such an organized way. As Green and Courtis point out in their article criticizing the use of information theory as a basis for study of form perception, people do not view their environment in an organized one-piece-of-information-at-a-time manner.[25] The Gestalt viewpoint suggests much more freedom of scanning.

It could be, too, that the small area of the designs required little effort to scan, and in fact, it might require more effort on the part of a person to control his scanning to stop on one side or the other of a design. In situations where the subject is close to a very large and/or very complex design, the notion of clustering fixations for symmetrical designs seems more reasonable. For example, a person standing a short distance from two designs of billboard size might find that more effort in terms of neck turning and body movement is necessary to scan asymmetrical designs than symmetrical designs because most of the gazes in the symmetrical designs could be clustered on one side of the vertical axis.

Asymmetrical designs were not perceived as more complex or interesting than symmetrical ones, but figures with an increased number of contours were perceived as more complex and interesting. This lesser contribution of symmetry-asymmetry fits in with an earlier finding of Attneave regarding the various influences of physical variables such as symmetry, number of contour turns,

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[25] R. T. Green and M. C. Courtis, "Information Theory and Form Perception: The Metaphor that Failed," Acta Psychologica, Vol. 25 (1966), 12-36.

variability in size of angles, curvedness, and so on, to judgments of figural complexity.[26] As mentioned earlier, Attneave found that number of turns in the contour explained 78.7 per cent of the variance of complexity ratings. He found that symmetry explained only 3.8 per cent of the complexity variance. Attneave's findings together with the findings of the present study seem to indicate that symmetry plays a small part in people's judgments of figural complexity. If such is the case, this might carry over into judgments about interest--it does in the present findings.

The complete lack of support for symmetry in the present experiment is at odds with Berlyne's earlier findings. But he did not study symmetry versus asymmetry in connection with any other variables. It might be that symmetry is not a dimension of complexity; that it operates differently. Berlyne has discussed complexity as increasing with the number of perceived elements in a stimulus pattern. But in symmetrical designs, physical elements are not increased, as are contour angles, for example. A symmetrical design differs from an asymmetrical design only in that one side is the mirror image of the other. Perhaps there is less chance of an increase in "perceived elements" for the symmetrical-asymmetrical

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[26] F. Attneave, "Physical Determinants of the Judged Complexity of Shapes . . . ," op. cit.

variable than for a variable such as an increase in contour angles in which the number of physical elements does increase. It may be that complexity variables are alike in that they deal with amounts of physical elements; whereas, symmetry deals with arrangement of existing elements.

The above distinction ties in with a more recent study in which Berlyne has attempted to define the dimensions of judged complexity and has tentatively found two dimensions: one is the number of parts of the stimulus, and the other he terms the "unity" of the figure.[27] It might be that the unity dimension is related to the Gestalt concept of figural goodness. If so, symmetry might be related more to this second dimension than to the number of parts dimension, and might operate differently. Day also suggests that symmetry might be related to figural goodness.[28]

The Effect of Contour and Symmetry on Pleasingness

Neither contour variation or symmetry made a difference regarding pleasingness ratings. A few studies

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[27] D. E. Berlyne, J. Ogilvie and L. Parham, "The Dimensionality of Visual Complexity, Interestingness, and Pleasingness," Canadian Journal of Psychology, Vol. 22 (1969), 376-387.

[28] H. Day, "The Importance of Symmetry and Complexity in the Evaluation of Complexity, Interest and Pleasingness," Psychonomic Science, Vol. 10 (1969), 339-340.

have been performed studying pleasingness and complexity in addition to Berlyne, but the findings have not always been consistent. As mentioned previously, Day did a series of four studies relating contour and judgments of pleasingness.[29] He found that pleasingness fluctuated greatly and correlated only slightly with complexity, although, overall, pleasingness was slightly greater for lower levels of complexity. In one study Eisenman found no relation between number of contour angles and pleasingness.[30] In another, Eisenman and Robinson found that creative persons such as art students tended to prefer designs with more angles, while more naive subjects preferred figures with less angles.[31] However, Eisenman and Gellens later found that naive subjects preferred the figures which had more contour when the figures were symmetrically shaped.[32] The lack of predictability of contour and pleasingness in the present study and others suggests a need for greater definition of the role of contour and pleasingness. This same holds true for the

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[29] H. Day, "Evaluations of Subjective Complexity . . . ," op. cit.

[30] R. Eisenman, "Pleasing and Interest Visual Complexity . . . ," op. cit.

[31] R. Eisenman and N. Robinson, "Complexity-Simplicity, Creativity, Intelligence, and Other Correlates," Journal of Psychology, Vol. 67 (1967), 331-334.

[32] R. Eisenman and H. Gellens, "Preferences for Complexity-Simplicity and Symmetry-Asymmetry," Perceptual and Motor Skills, Vol. 26 (1968), 888-890.

lack of confirmation of the effect of symmetry on pleasingness. Perhaps a larger sample might have shown a more consistent relationship.

Future Research

Ideas for future research often derive from the restrictions a researcher found that he had to place on himself in his current study. For example, in this study a much larger random sample would be preferable to the restricted volunteer sample used here. A new method for collecting eye fixation data would be welcomed to avoid producing anxiety in the subject due to the strangeness of the device, the darkness of the room, and the artificiality of the experimental situation itself. (Even the elimination of the useful but awkward and messy bite stick would help.) Finally, although the artificiality and meaninglessness of the experimental material is necessary for control, it places the experiment in a rather nebulous unreal world. These kinds of thoughts are typical of researchers looking for the ideal experiment.

However, while the above desires are typical of many researchers, based on the results and implications of the present experiment, some major areas stand out for future study. First the amount of time the stimuli are exposed might be an important factor effecting the results of multi-stimulus studies. It would be useful to examine the affect of various exposure times in a study similar to the present one. Here a ten second exposure was used. Would the same findings have occurred for a two second or a five second exposure? Though the hypotheses studied in this experiment pertaining to symmetry were not confirmed, it seems possible that they would if a longer exposure time were used. Perhaps the subject did not have enough time to recognize that he was facing a symmetrical design. Only after he became aware of this would one expect him to spend considerable time looking at one side of the design. A study utilizing longer exposure times seems merited before the notion of the effects of symmetry on attention is cast aside.

The failure of the hypotheses about eye fixations clustering on one side of the vertical axis may be due to the necessarily small size of the designs used in this study. Four designs were used at a time, and the eye camera allows only a limited range of scanning. Therefore, it would seem worthwhile to retest the single-side clustering hypothesis using a single, very large design. With a very small design, the subject's peripheral vision may be enough for him to see the whole design without vertical or lateral eye movements. If a design is much larger, however, the vagueness of perception in his peripheral vision would be more likely to motivate the subject to search back and forth around different areas of the design. Thus, this one-side clustering hypothesis should be tested again with a larger stimulus.

The two replication interactions between contour variation and complexity and interest ratings suggest the study of overall complexity of sets or levels of design in comparison with one another. Berlyne has studied a similar kind of situation, but amount of contour was not the major distinction between his high and low sets of complexity figures.[33] Day,[34] Eisenman,[35] and Attneave[36] have all studied single figures and increases in the amount of contour change, and related contour change to either judgments of complexity, interest or pleasingness. In a future study it might be useful to test the influence of the overall complexity of a set of designs not only on judgments of complexity and interest but also on eye fixations. Thus designs from sets with more overall complexity would be compared with those of lesser overall complexity.

The two design strategies studied in this experiment were derived from Berlyne's study of attention.

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[33] D. E. Berlyne and S. Peckham, "The Semantic Differential and Other Measures of Reaction to Visual Complexity," Canadian Journal of Psychology, Vol. 20 (1966), 125-135. See also, for example, D. E. Berlyne and G. Lawrence, "Effects of Complexity and Incongruity Variables on GSR . . . ," op. cit.

[34] H. Day, "Evaluations of Subjective Complexity . . . ," op. cit.

[35] R. Eisenman, "Pleasing and Interest Visual Complexity . . . ," op. cit.

[36] F. Attneave, "Physical Determinants of the Judged Complexity of Shapes . . . ," op. cit.

One of the main notions in his theory is that, the greater the complexity of a stimulus, the more attention a person will pay to that stimulus up to an optimal level. In this experiment, two forms of complexity were studied. First, the number of angles in a design was defined as one operationalization of complexity. Second, asymmetrical designs were defined as more complex because they do not have the redundancy that symmetrical designs do (i.e., each side of an asymmetrical design has independent information). If Berlyne's general notion about complexity and attention is correct, both of these manipulations of complexity should have influenced attentiveness to the designs studied. That was not what happened.

The present study seems to indicate that Berlyne's earlier conceptualization of complexity was too broad and lends support to his more recent tentative findings about the dimensions of judged complexity. Complexity may be a multi-dimensional concept within which a number of kinds of complexity operate somewhat differently. In this experiment the number of contour angles produced the attention pattern that Berlyne predicted, but symmetry did not. Perhaps the several kinds of complexity that Berlyne described in his research should be studied in relation to one another to determine narrower dimensions of the concept and their differential effects on attention and judgments of complexity, interestingness and pleasingness. In addition to contour variation and symmetry, some other possible variables for future study are the size-area of the figure, the curvedness versus angles dimension, the difference in the width of the angles of a figure, and the depiction of three versus two dimensional space.

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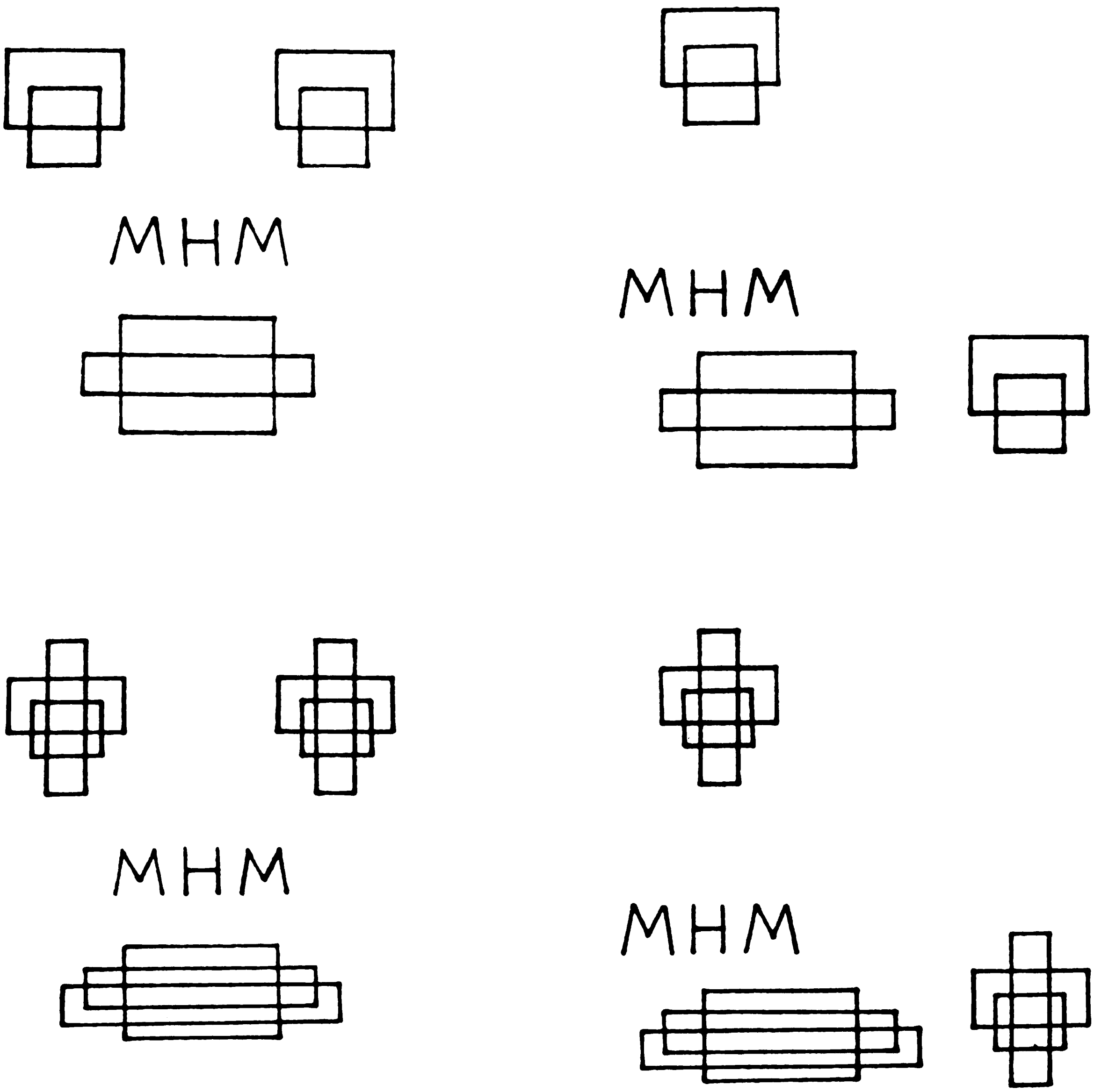
APPENDIX A

DESIGNS USED IN THE EXPERIMENT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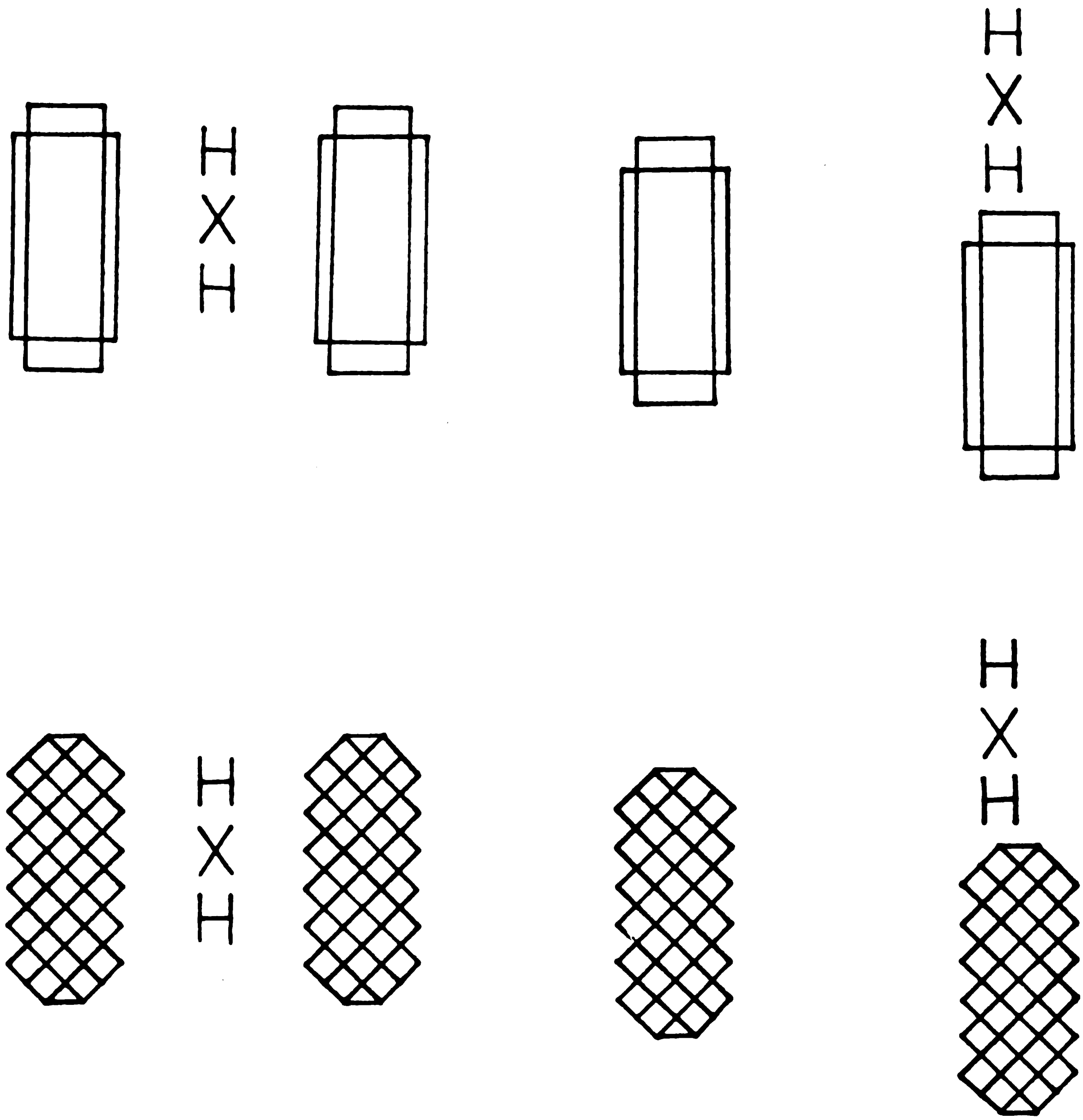
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APPENDIX B

SCHEDULE OF ACTIVITIES DURING EXPERIMENT

APPENDIX B

SCHEDULE OF ACTIVITIES DURING EXPERIMENT

Part I

1. Acquaint subject with eye camera.
2. Position head and body and adjust bite stick.
3. Calibrate eye fixations to test targets.
4. Show samples of figures and explain presentation procedures.
5. Operate camera to familiarize subject with sound.
6. Subject views calibration card with camera running and closes his eyes.
7. Subject opens eyes and views first set of designs for ten seconds, then closes eyes.
8. Views calibration card with camera running and closes eyes.
9. Opens eyes and views second set of designs for ten seconds, then closes eyes.
10. Three minute break.
11. Recalibration.
12. Subject views calibration card with camera running and closes his eyes.
13. Opens eyes and views third set of designs for ten seconds, then closes eyes.

14. Views calibration card with camera running and closes eyes.
15. Opens eyes and views fourth set of designs for ten seconds, then closes eyes.
16. Three minute break.
17. Recalibration.
18. Subject views calibration card with camera running and closes his eyes.
19. Opens eyes and views fifth set of designs for ten seconds, then closes his eyes.
20. Views calibration card with camera running and closes eyes.
21. Opens eyes and views sixth set of designs for ten seconds, then closes his eyes.
22. Three minute break.

Part II

1. Subject reads instruction sheet on how to use a rating scale.
2. Explain use of design flip cards and scale booklets.
3. Subject rates 24 designs on first scale (either complexity, interestingness or pleasingness).
4. Rates 24 designs on second scale.
5. Rates 24 designs on third scale.
6. Fills out personal information sheet.
7. Explain experiment to subject.