HUMAN EXPLORATORY BEHAVIOR AS A FUNCTION OF PERCEIVED INFORMATION

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CHAPTER I

REVIEW OF THE LITERATURE AND STATEMENT OF THE PROBLEM

Introduction

In general, research has shown that people tend to look at or "explore" stimulus patterns according to how much information they have in them (Berlyne, 1958 a; Cantor, Cantor and Ditrichs, 1963; Brown and O'Donnell, 1966). However, there seem to be exceptions to this rule. For instance, there is evidence to indicate that people do not look at curved shapes more than at angular shapes and that they don't look at shapes with more angles longer than they do shapes with fewer angles (Brown and O'Donnell, 1966; Brown and Lucas, 1966; Brown and Gregory, in Manuscript). One possible explanation for these exceptions is that certain "informational" variables are not <u>perceived</u> as being informational - at least over a range of levels. For example, a curved shape with four turns may not be perceived as containing more information than a quadrangle, or a 20-sided shape may not be perceived as containing more information than a 15-sided shape.

"Actual" information, as opposed to "perceived" information, is used in the nonstatistical sense that Attneave

(1957) uses the term "information", i.e., an absence of redundance. If one were to describe a stimulus pattern so that it could be reproduced, an "informational" variable would be one which would contribute to the amount of necessary description. Examples of informational variables would include the number of components comprising the pattern, and angular variance of the components (Brown, 1966). Non-informational variables would include color and border width, as changes in these do not alter the amount of necessary description.

In the present study, Berlyne's (1966) concept of a "specific exploratory behavior" was adopted. This is one of two proposed "kinds" of exploratory behavior, the other being "diversive" exploration.

Specific exploratory behavior is seen to have more immediate "survival value" as it results from a situation in which the organism is in a state of uncertainty or conflict due to a lack of information. If the situation is of some urgency, the behavior directed toward the immediate elimination of uncertainty could well mean the difference between life and death. The motivational state induced by this lack of information has been termed "perceptual curiosity" (Berlyne, 1966).

The presentation of stimulus patterns too briefly to allow time for their characteristics to be identified has been used as one method of inducing specific exploration (e.g. Berlyne, 1963 b). This research has shown that patterns high in informational content (i.e., "complex"), when briefly presented, are chosen more frequently for subsequent examination than patterns relatively low in informational content (i.e., "simple" patterns).

Diversive exploration occurs in a situation in which perceptual curiosity is at a minimum. For example, the presentation of a stimulus pattern long enough that the informational content can be abstracted would be conducive to diversive exploration. Under this motivational state, "curiosity" plays a minor role and "an animal seeks out stimulation, regardless of source or content, that offers something like an optimum amount of novelty, surprisingness, complexity, change, or variety" (Berlyne, 1966).

Review of the Literature

The areas of investigation most pertinent to this study consist of efforts toward the quantification of visual-form parameters and the relating of the physical parameters of visual stimuli to human exploratory activity.

Quantification of Visual Form Parameters

According to Michels and Zusne (1965) the impetus behind the recent attempts at the quantification of physical form parameters can be traced to information theory. This interdisciplinary study defines information as "a purely quantitative property of an ensemble of items that enables categorization or classification of some or all of them"

(English and English, Pp. 261, 1958).

Physical measures of the amount of information or "complexity" of visual patterns have often been based on the rationale that it is the number of elements contained in the stimulus pattern that determines, at least for the most part, its informational load. Papers by Attneave (1954) and Attneave and Arnoult (1956) have argued that contours are regions of high informational content and that information is concentrated at the points in the contour where the change in gradient is steepest (e.g., verticies). A study conducted by Hochberg and McAlister (1953) used as stimulus dimensions number of angles, number of line segments, and points of intersection of complex line figures. An inverse relationship was found between response probability (i.e., the probability of a bidimensional perception of Kopfermann cubes), and the amount of information (e.g., number of angles) required to define the pattern eliciting a response.

In a more recent effort, Michels and Zusne (1965) have classified the quantification of physical form parameters into three main types. The classification is based on whether changes in the magnitude of the parameter affect the information content, the structure of the component, or both: Transitive parameters are those which affect the informational content as well as the structure of the component so greatly that it is placed in another population of components. Examples would include the number of independent turns (i.e., the total number of sides in asymmetrical shapes and one-half the total number of sides in even-sided, symmetrical shapes) in the contour, angular variability of the contour, and curvature. Transpositional parameters are those which do not alter the informational content of the shape but do change its retinal image as it is enlarged, moved, or rotated from its original position in the pattern. The intransitive parameters affect the structure of the component but not its informational content. For example, a three-sided figure is still seen as a triangle even though it is made thinner or more symmetrical.

Based upon earlier work of Attneave and Arnoult, Brown (1964) compiled a list of stimulus properties by which to quantify visual patterns. The properties are classified as follows: (1) component variables - properties which define the individual shapes or "components" of a pattern; (2) pattern variables - properties which describe the relations among the components making up the pattern, and; (3) arrangement variables - properties which refer to the various rules by which components may be ordered within a pattern. Stenson (1966), in a study relating physical structure of random forms (constructed according to Method 4 of Attneave and Arnoult, 1956) to judged complexity, has compiled a list of twenty-four physical measures by which to quantify the random forms. Included within this list are number of turns, the area encompassed by the perimeter, the length of the perimeter, and the ratio of the number of arcs to the number of turns. All of the twenty-four are properties by which to quantify the individual shapes but none deal with the arrangement or placement of the shapes into a pattern.

Relating of the Physical Parameters of Visual Stimuli to Human Exploratory Activity

Berlyne (1958 a) presented patterns of varying degrees of "complexity" to 3- to 9-month-old infants and recorded the pattern which elicited their first fixation. The most "complex" stimulus in each series of three patterns was found to be significantly more likely to attract first fixations. Also, the two stimulus patterns in the series containing the more contour elicited a greater amount of "attentive" behavior than did the other. Using pre-school children as Ss, Cantor, Cantor, and Ditrichs (1963) found a significant complexity-level effect in relating stimulus complexity to observing responses. It was found that the Ss spent more time observing "highly complex" patterns as compared with medium or low complexity patterns. Berlyne (1958 b), using human adults as Ss, simultaneously presented a "less complex" and a "more complex" stimulus pattern for 10 seconds and recorded which pattern elicited the first fixation, as well as the amount of time the S spent viewing each pattern. The six "complexity" variables included irregularity of arrangement, amount of material (one figure in each pair consisted of part of the material in the accompanying figure), heterogeneity of elements, and irregularity of shape. Although no significant complexity effect was found for first fixations, the "more complex" patterns were viewed significantly longer than were the "less complex" for each of the six variables investigated.

The general finding that Ss spend more time looking at the more complex patterns is contested somewhat by the results of a study by Hoats, Miller, and Spitz (1963). A group of retardates, a group of normal children of equal mental age, and a group of normal children of the same chronological age were used as Ss. Each S was first presented two patterns simultaneously and then allowed a subsequent view of either pattern he preferred for as long as he wished. The result was that less irregular patterns were chosen significantly more often for subsequent viewing than were the more irregular patterns. Berlyne (1963 b) modified the experiment by using a range of initial exposure durations consisting of 0.5 seconds, 1 second, 3 seconds, and 4 seconds. Results indicated a tendency among Ss to select for subsequent viewing the more irregular patterns when the initial exposure duration was either 0.5 seconds or 1 second and to select the less irregular when initial exposures were 3 or 4 seconds. Berlyne interpreted this finding in terms of his concepts of "specific" and "diversive" exploration. It was reasoned that initial exposures of 1 second or less were not long enough for the S to abstract all the information and, hence, he was in a state of "perceptual curiosity", while exposure of 3 or 4 seconds provided ample time for the abstraction of the information and the resultant exploration was due to factors most properly classified as "diversive".

Studies by Brown and his associates (Brown and Farha, 1966; Brown and Lucas, 1966; and Brown and O'Donnell, 1966), using the length of viewing time as a measure of exploration, have obtained similar results. Brown and Farha (1966), using "neutral", "interestingness", and "pleasingness" instructional sets, found that patterns with larger areas were viewed longer than patterns with smaller areas under all conditions. However, patterns containing 9-sided shapes were viewed longer under "neutral" and "interestingness" sets, whereas 3-sided shapes were viewed longer under the "pleasingness" set. Brown and O'Donnell (1966) and Brown and Lucas (1966) found viewing times to be significantly influenced by both number of components and angular variance. Dissimilarity of the border width of the components was found to be significant in the Brown and Lucas (1966) study, while both Brown and O'Donnell (1966) and Brown and Lucas (1966) found no significant effect of number of turns. It is of interest to note that "non-informational" variables such as color and border width (Brown and Farha, 1966, and Brown and Lucas, 1966, respectively) were found to have no significant effect on time spent viewing patterns.

Similar studies have attempted to relate physical parameters of visual patterns to subjective factors by means of the "verbal report". In general, Ss are presented a series of patterns varying over a range of physical dimensions and requested to rate, or rank, them according to various instructional sets such as "pleasingness", "interestingness", "like-dislike", "complexity", etc. Attneave (1957), using this method, found that 90% of the variance in complexity judgments could be explained by the number of turns, the angular variability, the ratio of the perimeter squared over area, and the symmetry of the shapes. However, angular and curved shapes were rated as being equally complex. Similar results were found by Stenson (1966), with number of turns, length of the perimeter, ratio of the perimeter squared over area, and angular variability accounting for most of the variance in complexity ratings. With the exception of length of perimeter, these were the same variables found by Attneave (1957) to influence complexity ratings.

The results of a study reported by Berlyne (1960, Pp. 230) showed that when Ss were presented with pairs of stimulus patterns of varying complexity and requested to rate each for "pleasingness" and "interestingness" there was a significant tendency to attribute more pleasingness to the less complex member of the pair, but more interestingness to the more complex. In a similar study, Berlyne and Lawrence (1964) found that Ss rated more irregular figures as less pleasing but more interesting.

One phase of the research conducted by Weiner (1967) consisted of requesting Ss to rate stimulus patterns as to "attractiveness". Of the three informational variables investigated, the number of components making up the patterns and the variation in the distances separating adjacent components (i.e., proximity variance) were found to significantly influence attractiveness ratings. However, the third variable (curved vs. noncurved components) failed to be of significance. However, curvature did show a significant interaction with the number of components. Examination of the interaction reveals that, for patterns with three or six components, angled ones received higher mean ratings than did the curved but, for patterns with 12 components, a reversal took place as curved shapes received higher ratings for patterns containing both 12 and 24 components. Also, a significant number of components X proximity variance (i.e., variability in the distances between adjacent shapes) interaction was obtained. Examination of this interaction reveals that low proximity variance patterns received higher "attractiveness" ratings over all levels of number of components, with patterns containing 12 components showing the greatest difference between the two levels of proximity variance.

Heckhausen (1964), in a review of one of Berlyne's studies, suggests a position similar to that under investigation in this study. In the study by Berlyne (1963) it was found that Ss did not consistently prefer less orderly (i.e., more complex) patterns but often chose the more orderly patterns. He attributed this finding to his concept of two distinct "kinds" of exploration - "specific" and "diversive". Heckhausen contends that degree of complexity, as quantified by information theory, is often quite different from the level of "perceived" complexity and that it is this perceived, or phenomenal, complexity which influences exploratory activity. The patterns which were less complex from the physical point of view were in fact held to be perceived to be more complex, as they contained enough symmetry, or redundancy, that the Ss could discern patterns and relationships among the various parts and form associations among them.

In general then, research tends to show that both human exploratory responses and subjective evaluations are affected by visual complexity (i.e., information content), although both types of behavior tend to be affected in oposite ways, i.e., exploratory behavior increases with complexity while verbal ratings of, for example, "attractiveness" decrease. However, some interesting exceptions have been found, some of which may possibly be interpreted in terms of "specific" and "diversive" exploration (i.e., changes in preferences for patterns resulting from increased initial exposure time). Other exceptions, however, are as yet largely unaccountable (e.g., the failure of "curvature" and number of turns to affect viewing times).

Statement of the Problem

The purpose of this study was to investigate the relationship between human exploratory behavior and several variables which contribute to the informational content of patterns, and to propose an explanation for any possible discrepancy between the two in terms of the processing of information under a "task-oriented" instructional set. It was suggested that, should exploratory behavior not invariably increase as a function of actual information, the explanation might be sought in terms of how the observer processes the information contained within the pattern *when* he is attempting to learn about it for purposes of some future utilization. In order to investigate this proposition, two experimental situations were utilized: first, a specific exploratory situation designed to measure task-oriented processing of information in which it was necessary for the *S* to seek out the informational content of the pattern in order to perform a subsequent "matching" task; second, a "free-viewing" situation in which the *S* was simply instructed to view a series of patterns for as long as he "wished".

It was assumed that, should exploratory behavior in a free-viewing situation be governed by the processing of information for purposes of future retention, differences in viewing times (VT's) of the patterns in the "free-viewing" situation would correspond more closely to the differences in the task-oriented processing of information, based on the VT's of the specific exploratory group, than to differences in "actual" information. The particular information variables selected for investigation were number of components (NC), proximity variance (PV), and curvature.

CHAPTER II

METHOD

Subjects

One hundred and twenty-eight undergraduate volunteers enrolled in introductory psychology courses at Oklahoma State University were assigned to one of two groups with 80 _S_s being assigned to the specific exploratory group (SEG) and 48 to the free-viewing-time group (FVTG). An attempt was made to balance the groups as to sex, with approximately 40 of each sex assigned to the SEG and 24 of each sex to the FVTG. The FVTG was further divided into eight subgroups of six _S_s each, with each subgroup corresponding to one of the eight orders of presentation of the stimulus patterns. The ratio of male to female was also controlled within these subgroups, with 3 to 3 being the ideal, but, due to the availability of slightly more women than men, a 2 to 4 ratio was occasionally employed.

Stimulus Patterns

The stimulus patterns used were the same as those used by Weiner (1967). Each of the 16 stimulus patterns represented one cell in a 4 X 2 X 2 factorial design, the three factors being number of components (NC), proximity variance

(PV), and curvature. Four of the patterns are presented in Figure 1.

The four levels of NC were 3, 6, 12 and 24, referring to the number of shapes making up a given pattern. For example, a pattern at the second level of NC would contain 6 individual shapes. Weiner (1967) described the method employed in the construction of shapes as follows:

> The shapes were three eight-sided polygons constructed according to Method 1 and Method 4 of Attneave and Arnoult (1956). Method 1 consists of constructing a matrix (25 X 25 in this case) from graph paper and plotting points using a table of random numbers. The most peripheral points are then connected forming a polygon having only convex angles. Points falling within the periphery are assigned letters, and the sides of the polygon are assigned numbers. The table of random numbers is then used to determine which of the central points is connected to which side. Each step in this procedure is determined either randomly or by the elimination of all other possibilities.
>
> Method 4 is the procedure for making wholly or partially curved shapes from the angular shapes constructed by Method 1. Briefly, each angle in each shape was bisected, 50% of the length of the shortest side was arbitrarily chosen (this is a slight modification from Attneave and Arnoult's use of a randomly chosen distance), and a perpendicular was drawn from this point until it intersected the angle's bisector. The distance between the mid-point of the shortest side and the angle bisector then became the radius of the arc used to curve the angle.

After completion, the shapes (consisting of three angular and three curved) were photographically reduced or enlarged in order to maintain their size at a constant area of 200 mm^2.

The factor proximity variance (PV) refers to the variation of the distances between adjacent shapes on a given

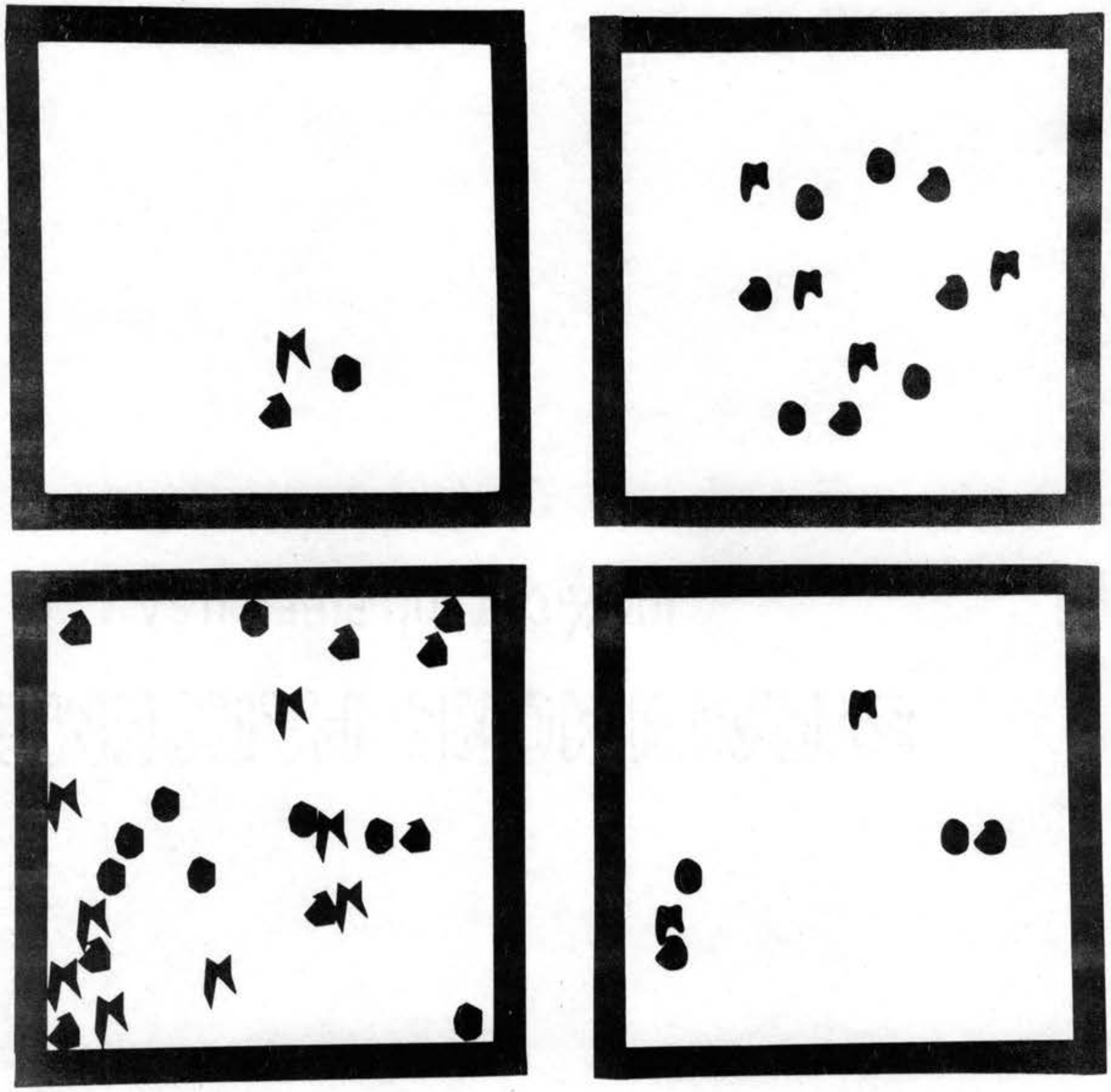

Figure 1. Reproductions of four of the stimulus patterns. Pattern 1 (upper left) contains three angular components with low-PV, Pattern 10 (upper right) contains 12 curved components with low-PV, Pattern 15 (lower left) contains 24 angular components with high-PV, and Pattern 8 (lower right) contains six curved components with high-PV. The black frames have been added for purposes of delineation.

pattern. The two levels of PV were high, with a mean value of 6.23 cm., and low, with a mean of 0 cm.

The construction of the stimulus patterns followed, with slight variations, a method described by Brown (1966). A prototype was prepared for the 24-component pattern and from it were derived the 12-, 6- and 3-component prototypes. To prepare the 24-component, high PV prototype, a 25- X 25-cm. grid was constructed and from this grid 24 cells were chosen by means of a random number table. However, in order to prevent the overlapping of the components in "adjacent" cells (measurements taken from each cell to the cell nearest it), a necessary restriction was that cells chosen to contain a component have not less than one unselected cell separating them. Measurements of the distances between "adjacent" cells were taken and the mean and variance of these distances was computed. These computations revealed a mean distance between adjacent cells of 2.2 cm. and a PV of 6.06 cm. From this "master" pattern, the 12-, 6-, and 3-component patterns were derived by using the same cells as the 24-component pattern, with the stipulation that their means and PV's be as close as possible to those of the 24-component pattern. For these patterns it was found that the mean distance ranged from 1.8 to 2.27 cm. and the PV ranged from 6.12 to 6.48.

The 24-component pattern prototype for the low-PV patterns was constructed utilizing the same procedure described above, with the restriction that the "adjacent" cells should have a distance of 2 cm. separating them. Under this restriction it was possible to obtain a 24-component pattern with a mean distance separating adjacent cells of 2.0 cm. and a PV of 0.0 cm.

The construction of the 12-, 6-, and 3-component low-PV patterns followed the same procedure as had been used for the high-PV patterns. Thus, the mean distance and the proximity variance were 2.0 cm. and 0.0 cm., respectively, for each of the low-PV patterns.

In determining the placing of the shapes upon the pattern, the three angular shapes were assigned to previously selected cells at random with the restriction that an equal number of each shape appear in a given pattern. Once a shape had been assigned to a given cell it continued to occupy that cell in all other patterns with the same PV which used that cell as a component. The curved shapes occupied the same positions in the patterns as had the angular shapes from which they were derived. All shapes were given a vertical orientation (see Brown, 1964). As the shapes had an area of 200 mm^2 and the cells to which they were assigned an area of only 100 mm^2, it was necessary to center the shapes on their respective cells by eye and draw them on the pattern.

In preparing the 16 stimulus patterns for photography, each was placed over a piece of heavy white vellum paper and small pin marks were made along the contour of every shape, thus outlining the contour of each shape on the particular pattern. The shapes, having been cut from black construction paper, were cemented to the white paper, the pin marks of the contours serving as guides to their placement. After this was completed, the patterns were photographed and prepared in the form of both 2- X 2- in. slides and 25- X 25- cm. prints. For the slides the shapes appeared as black upon a white translucent background, and as black against a white background for the prints.

Apparatus

The stimulus patterns which had been prepared in the form of 25- X 25- cm. prints were mounted on a 44- X 44- in. piece of white posterboard, forming four columns and four rows. The patterns were attached to the posterboard by "picture hangers", so that the arrangement of the patterns could easily be varied. The posterboard with the patterns was then attached to a wall of the experimental room with the bottom of the posterboard being 24 inches above the floor. The ordering of the patterns on the posterboard was governed by five randomized spatial arrays. Five random arrangements were necessary as the Ss in the SEG were assigned to groups of five and, thus, one S in each group was shown the same spatial arrangement.

A Wollensak Alphax automatic shutter, set for 4 seconds, was mounted in a 4- X 4- ft. black, plywood shield. This shield was placed on a table 30 inches in height positioned 5 feet in front of the posterboard mounted on the wall. The shield effectively blocked the wall display from the view of anyone entering the experimental room so that the only way it could be seen was through the shutter.

The apparatus also included a chair positioned immediately to the left of the shield and table, with a telegraph key attached to its arm, and a black wooden screen measuring 7 feet wide and 5 feet high positioned 4 feet directly in front of the chair. The screen contained a 25- X 25- cm. window covered with tightly stretched tracing paper. The chair was positioned so as to be in line and at "eye-level" with the window for anyone sitting in the chair, and also in line with and at "eye-level" to the shutter immediately to the right of the chair. The arrangement was such that anyone sitting in the chair saw the 25- X 25- cm. window directly in front of him or, upon turning to the right, was in position to place his eye against the shutter which, when opened, afforded an unobstructed view of the wall display.

Behind the screen a slide projector (Airquip Superba 77) was positioned so as to project directly onto the window. The slides were placed in the projector so that when viewed from the front of the screen the patterns appeared in the same orientation and dimensions as those on the wall display. The projector was also equipped with a solenoid-operated shutter. The telegraph key on the chair, the shutter attached to the projector, and the projector were so connected with a Marietta interval-timer that pressure on the key served to simultaneously close the shutter, advance the slide magazine of the projector, and reopen the shutter. The apparatus also included an event recorder which recorded the opening and closing of the shutter-mechanism.

The experimental room was without windows except for one in the door which was covered with black cloth for the experiment. The arrangement of the apparatus was such that upon entering the room S saw only the front of the screen, the black shield in which the shutter was mounted, and the chair with the telegraph key.

Procedure

The SEG had 16 subgroups (one subgroup for each of the 16 stimulus patterns) with five Ss being assigned to each subgroup. The procedure was to arrange the 16 patterns on the wall display according to one of five random orders and to leave them in this order until 16 Ss had been run, with each S receiving one of the 16 patterns as the one which he was required to examine in order to complete a matching task. When 16 Ss had been run, the random order was changed and this method was continued throughout, until 16 responses had been taken for each of the five random orders. The result was five responses (viewing times) for each of the 16 stimulus patterns with one response per pattern for each of the random orders.

In discussing the procedure for the SEG, it is convenient to consider three main phases: (a) the brief, simultaneous presentation of all 16 stimulus patterns, (b) the individual examination of one of these patterns, and (c) the subsequent matching of this pattern with its identical counterpart among the 16 previously viewed patterns.

S was met in the laboratory and instructed to leave books, coats and other accessories before being escorted to the experimental room. After S was seated comfortably, E read the following instructions to him:

> On the wall behind this shield are some patterns which you will use in a later task. I am now going to show these patterns to you. When I say "ready", I want you to place one eye as close to the shutter as you can. Keep the other eye closed and look straight into the shutter. When I open the shutter I want you to scan the patterns as quickly and as thoroughly as you can. I will control the length of this viewing time so just try to see as much as you can in the time allowed. Are there any questions?

When S was positioned properly, the shutter was opened and held for 4 seconds, affording S an unobstructed view of the 16 stimulus patterns on display behind the shield.

The setting of the exposure time at 4 seconds was the result of a pilot study conducted specifically to determine an appropriate exposure time. "Appropriate" in this case was an exposure time which resulted in a maximum difference in subsequent viewing times between simple and complex patterns. It was assumed that such an exposure time would lie somewhere between the extremes of complete information (i.e., long preliminary exposure time) and no information (i.e., no preliminary exposure time), being long enough to minimize uncertainty regarding the general nature or class of patterns, yet short enough to prevent familiarity with specific patterns. The procedure for this pilot study was very similar to that employed for the SEG of the present study and can be summarized by again referring to the three main phases mentioned above. Six preliminary exposure times were tested and ranged from no preliminary presentation to a presentation of 60 seconds with 2, 4, 8, and 12 seconds being the intermediate levels. An analysis of variance of the results showed a significant difference in viewing times between simple and complex patterns, but no effects due to preliminary exposure time were found. The preliminary exposure time of 4 seconds was selected for future use as it appeared to yield a large difference in viewing times between complexity levels yet produced relatively small within-group variation.

After the S had viewed the 16 stimulus patterns on display for the allotted 4 seconds, phase b of the procedure was entered. At this time the following instructions were read to the S:

> One of the patterns which you saw on the wall is now going to be presented on this screen. I want you to examine the pattern quickly but thoroughly for once you have seen it, you will be asked to go behind the shield and point out which pattern on the wall it matches.
>
> For this phase you will use the key attached to the arm of the chair. When I tell you "start" I want you to press the key briefly but firmly one time. This will present the pattern on the screen. After you have pushed the key move your hand to your lap and keep it there so as not to trigger the projector accidently. Look at the pattern as long as you feel is necessary for you

> to match it afterwards. When you feel you will be able to make a correct match, quickly press the key again and the pattern will be turned off. Look at the pattern only for as long as you think is necessary to make a correct match.
>
> REMEMBER, to present the pattern on the screen, push the key one time and move your hand to your lap. When you are through looking at the pattern press the key again and the pattern will go off. DO NOT BEGIN UNTIL I SAY "START". Are there any questions?

If there were no questions, the E retired behind the screen, turned on the projector and told the S to "start". The length of time the S spent viewing the one pattern under these instructions was recorded by the event recorder. When the S again pressed the key, removing the pattern from his view and shutting off the event recorder, the E turned off the projector, reappeared from behind the screen and escorted the S behind the shield where phase c was initiated by requesting him to "take your time and look at all the patterns before making a selection". When the S had made his selection, the E thanked and dismissed him and assigned the number to his time reading (as recorded by the event recorder) which had previously been assigned to the record which contained his name, sex, and group number. If the S failed to make a correct match of the pattern which he had viewed individually with its counterpart on the wall display, his response measure was discarded and another S's response was obtained to take its place. Although the random order was not changed until 16 Ss had been run, it was necessary for the E to change the stimulus pattern in the slide magazine after each correct match so that each S would see the appropriate pattern. After placing the appropriate stimulus pattern in the projector and checking to see that the patterns on the wall were in the appropriate random order (changing the order when necessary), the E returned to meet the next S.

The procedure for the FVTG was somewhat less involved than was that for the SEG, as neither a preliminary exposure time nor a subsequent matching task was necessary in the free-viewing situation. The S was again escorted to the experimental room and when comfortably seated given a copy of the following instructions to follow as the E read them aloud:

> A series of patterns will be presented in this window. The length of each presentation will be up to you. Look at each pattern for as long as you like, and, when you don't wish to see it any longer, press this button and the next pattern will be presented. When you press the button, press it briefly but firmly and then withdraw your hand completely and place it in your lap. If you don't keep your hand at some distance from the button, you may accidently trigger the apparatus before you wish to. You will not be tested on what you see or on any other aspect of the situation and there will be no shock or pain involved.
>
> Remember, look at each pattern only as long as you wish and then press the button and a new pattern will appear. I will tell you when to begin, and I also will tell you when the end of the series has been reached. Are there any questions?

If no questions were raised, the E retired behind the screen, turned on the projector and instructed the S to "start". The pressing of the key presented the first pattern and each "press" thereafter served to remove that pattern and present the next one until the end of the series had been reached. The event recorder connected to the key provided a measure of viewing time for each of the patterns.

A series consisted of 20 slides; four practice patterns followed without break in timing or signal of any kind by the 16 experimental patterns. The practice patterns were used to reduce the effects of novelty on S's viewing time. These practice patterns were in reality duplicates of four of the experimental patterns so selected as to represent all levels of all variables an equal number of times. For example, one practice pattern might have contained three components, high PV, and 50% curvature; another, six components, low PV, and zero curvature; another would have 12 components, high PV, and zero curvature. Then, the fourth and final pattern would have to have contained 24 components of low PV and 50% curvature. The order of presentation of the experimental patterns was according to eight random orders with six Ss receiving the same order. For the practice patterns an individual randomization was assigned to each S. Sixteen practice sets were compiled and presented to the first 16 Ss before starting over again with the same 16 sets. This method assured that each stimulus pattern would serve in a practice set an equal number of times as 16 divides evenly into the total number of Ss, 48. All patterns were presented in the same spatial dimensions as the inked originals.

When the end of the series had been reached the E turned off the projector, thanked and dismissed the S, and assigned the number to his response tape which had been assigned to the record containing his name, sex, and group number. The E then repositioned the patterns in the slide magazine, changing the random order when appropriate, before returning to meet the next S.

CHAPTER III

RESULTS

Specific Exploratory Group

For the SEG, 80 viewing times (VT's), each accurate to the nearest .25 second, were obtained with five VT's for each of the 16 stimulus patterns. The analysis of these VT's was accomplished by means of an analysis of variance (AOV), with the data in a 4 X 2 X 2 factorial arrangement. The analysis (see Table I) revealed that of the three factors, only the main effect of number of components was significant ($F = 8.36$, $df = 3/64$, $P < .005$). None of the other main effects or interactions approached significance. A plot of mean VT's against increasing levels of NC (Figure 2) reveals a monotonic relationship as mean VT's increased with increasing levels of NC (M's = 6.56 sec., 10.66 sec., 14.20 sec., 20.12 sec for 3-, 6-, 12-, and 24-component patterns, rexpectively). Although not reaching significance, the means for the two levels of PV suggest that *Ss* viewed the high PV patterns slightly longer than the low PV patterns (M's = 13.03 sec. and 12.75 sec., respectively), and means for the two levels of curvature suggest that the angular patterns were viewed longer than the curved (M's = 13.85 sec., angular patterns, and 11.93 sec., curved).

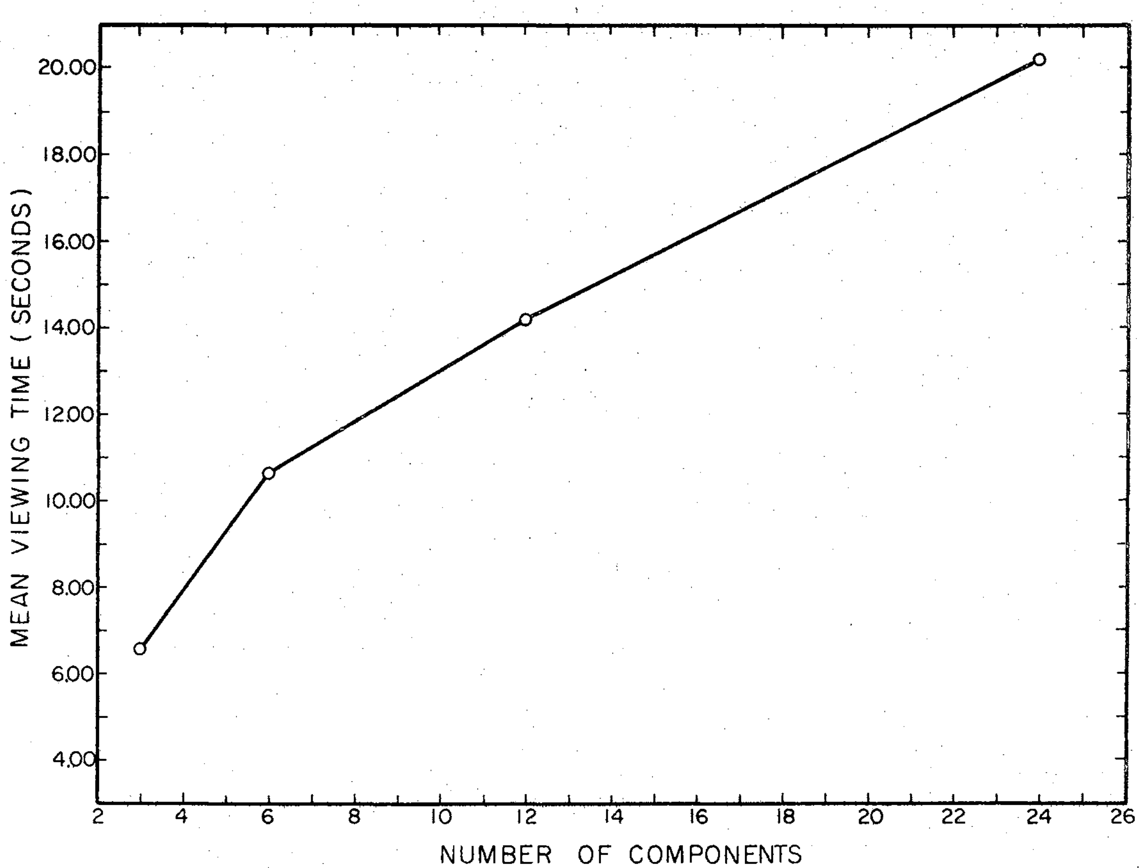

Figure 2. Mean Viewing Times of SEG

TABLE I

SUMMARY OF ANALYSIS OF VARIANCE
FOR SEG

Source	df	MS	F
Number of Components (NC)	3	660.40	8.36 **
Proximity Variance (PV)	1	1.51	
NC x PV	3	97.93	
Curvature (CV)	1	74.11	
NC x CV	3	72.88	
PV x CV	1	103.51	
NC x PV x CV	3	149.49	
Within Cells (error)	64	79.03	
Total	79		

** $P < .01$

Free Viewing Time Group

Sixteen VT's, each accurate to .25 of a second, were recorded for each S. These VT's were analyzed by means of an AOV, with the data in an 8 X 4 X 2 X 2 factorial arrangement, with repeated measures taken on the three stimulus variables (see Table II).

The AOV revealed the main effect of NC to be highly significant with mean VT's increasing as NC varied from 3 through 24 (M's = 3.82, 4.95, 5.44, and 6.24 sec. for the 3-, 6-, 12-, and 24-component patterns, respectively; $F = 40.24$, $df = 3/120$, $P < .005$). Also, patterns of high PV evoked significantly longer VT's than patterns of low PV (M's = 5.23 and 4.99 sec., respectively; $F = 8.22$, $df = 1/40$, $P < .01$). The main effect of curvature was not significant, a finding compatible with results obtained by Brown (1967); however, curvature did interact with the order of presentation of the stimulus patterns ($F = 3.74$, $df = 7/40$, $P < .005$). These results must be qualified, however, by the appearance of a significant NC X PV interaction ($F = 4.92$, $df = 3/120$, $P < .005$; see Table II) and, also, by the appearance of a significant Order of presentation X NC X Curvature interaction ($F = 3.32$, $df = 21/120$, $P < .005$).

In order to investigate the nature of the NC X PV interaction, a graph was constructed showing mean VT's for patterns of 3-, 6-, 12-, and 24-components as a function of degree of PV (see Figure 3). Also, tests of the simple

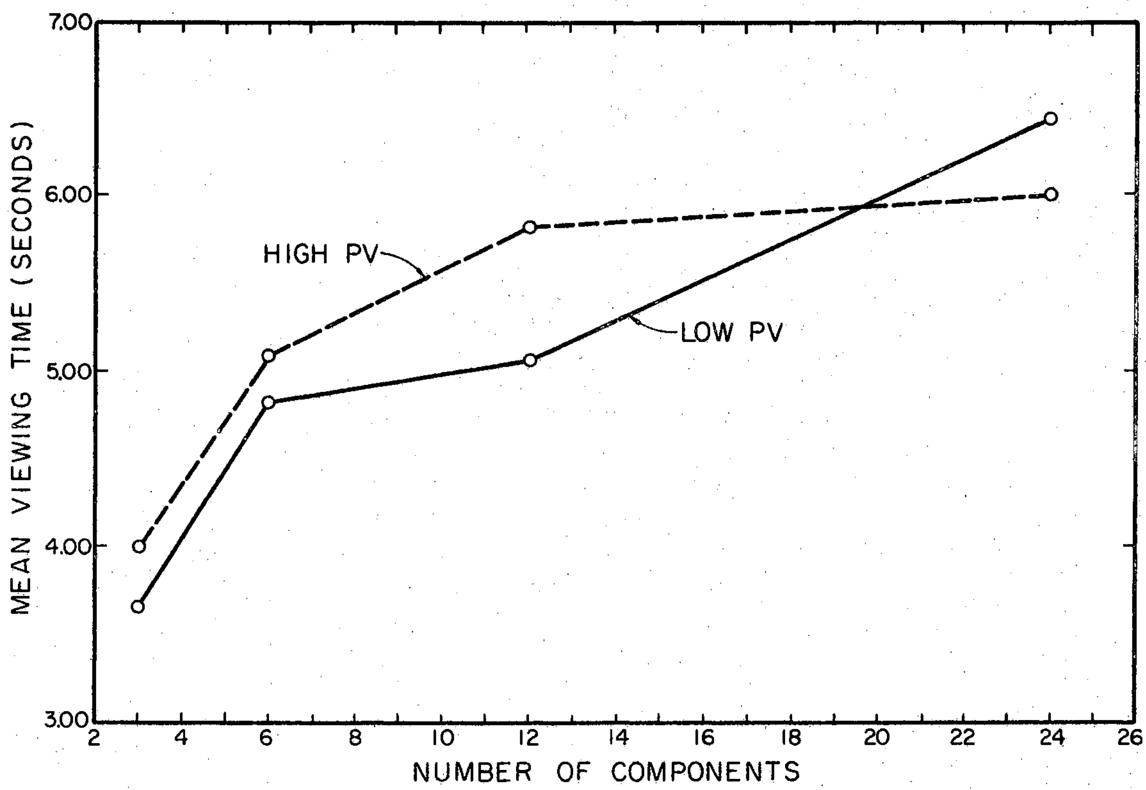

Figure 3. NC X PV Interaction for FVTG

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE FOR FVTG

Source	df	MS	F
Between Subjects	47		
Order (A)	7	10.62	
Subjects within groups	40	53.05	
Within Subjects	720		
No. of Components (B)	3	195.99	40.24***
A X B	21	4.56	
B X Sub./groups	120	4.87	
Proximity variance (C)	1	22.01	8.22**
C X A	7	2.07	
C X Sub./groups	40	1.34	
Curvature (D)	1	1.78	
D X A	7	7.55	3.74***
D X Sub./groups	40	2.02	
B X C	3	10.82	4.92***
B X C X A	21	3.52	
BC X Sub./groups	120	2.20	
B X D	3	2.09	
B X D X A	21	8.37	3.32***
BD X Sub./groups	120	2.52	
C X D	1	0.00	
C X D X A	7	1.90	

TABLE II (CONTINUED)

Source	df	MS	F
CD X Sub./groups	40	3.52	
B X C X D	3	0.23	
B X C X D X A	21	3.23	
BCD X Sub./groups	120	2.42	
TOTAL	767		

** $\underline{P} < .01$

*** $\underline{P} < .005$

effects of PV were conducted, revealing that patterns of high PV were viewed significantly longer than low-PV patterns when NC was 12 ($\underline{F}$ = 13.39, $\underline{df}$ = 1/160, $\underline{P}$ < .01), but did not receive significantly longer VT's when NC was either 3 or 6. For patterns containing 24 components, however, the effect of PV was reversed, with mean VT's for low-PV patterns being larger than those for the high-PV patterns ($\underline{F}$ = 3.88, $\underline{df}$ = 1/160, $\underline{P}$ < .06).

Additionally, tests on the differences between all possible pairs of means were made at each level of PV using the Newman-Keuls procedure (Winer, 1962, Pp. 309-310). It was found that for patterns of low PV all differences between adjacent means were significant ($\underline{P}$ < .05) except for the one between the 6- and 12-component patterns, and, for high-PV patterns all differences between means were significant except for that between the 12- and 24-component means.

The Order X NC X Curvature interaction was investigated by plotting mean VT's for the 3-, 6-, 12-, and 24-component patterns as a function of level of curvature for each of the eight orders of presentation. A comparison of these eight graphs revealed one or two reversals for seven of the eight orders in the tendency for patterns containing greater numbers of components to elicit longer VT's. One order led to no reversals, and for all but one of the eight orders no more than one reversal was found within any one function. With only one exception the reversals occurred between patterns with 6-, 12-, 24-components and (3-component curved patterns elicited longer VT's than 6-component patterns in one of the orders). However, the examination revealed no systematic relationship between the location of the reversals, the level of curvature, and the sequence in which the eight orders were presented. (Reversals occurred in the same locations in the functions for both angular and curved patterns with approximately equal frequency.)

As the eight orders had been equated to the greatest extent possible as to the number of individuals of each sex assigned to them, sex was discredited as a possible source of interaction.

CHAPTER IV

DISCUSSION

If the absence of clear, positive relationships between the physical informational content of visual patterns and exploratory behavior is to be accounted for in terms of the manner in which the information is processed when the observer views the patterns under a task-oriented set, it becomes necessary to show (a) that discrepancies occurred between the physical information of the patterns and the manner in which the information was processed under task-oriented instructions (as measured by the VT's of the SEG), and (b) that the VT's of the FVTG correspond more closely to those of the SEG. It should first be noted, therefore, that the VT's of the SEG did not in fact reflect the physical information of the patterns since both curvature and proximity variance failed to influence the viewing times of the SEG. The nonsignificance of curvature is consistent with the finding of Attneave (1957) that angular and curved shapes are judged as equally complex, and to the statement by Heckhauser (1964) that curvature contributes little to the "phenomenal" complexity of a pattern.

The results of the analysis of the exploratory behavior of the FVTG may be summarized by two of the significant interactions; the Number of Components X Proximity Variance interaction, and the Order of Presentation X Number of Components X Curvature interaction.

Upon examination, it may be seen that the Number of Components X Proximity Variance interaction does not lend itself completely to either the informational or the task-oriented point of view. Proximity variance did not significantly affect viewing times of patterns containing 3- or 6-components even though it would be expected to do so from the actual information standpoint. On the other hand, the finding of a significant proximity-variance effect, with high-PV patterns receiving the longer viewing times for 12-component patterns, is compatible with an informational interpretation. However, the reversal occurring between the 12- and 24-component patterns, with low-PV patterns being viewed significantly longer when the number of components was 24, indicates a negative relationship between exploratory behavior and amount of actual information.

Concerning the reversal in relative effectiveness of PV between the 12- and 24-component patterns, perhaps the 24-component high-PV patterns (see Figure 3) were not, in one sense, perceived to be so complex as the 24-component low-PV patterns. An examination of one of the 24-component high-PV patterns reveals that it is not unlike a section of plastered wall which, although containing a great deal of "actual" information, would not elicit prolonged examination, perhaps because it goes beyond some subjective level of information beyond which the individual tends to alter the "level of exactness" at which he abstracts the information (cf. Attneave, 1954; Brown and Gregory, in Manuscript). It might be suggested, therefore, that viewing times increase as a function of informational content of patterns up to a certain point. However, when the amount of information approaches the level at which, in subjective terminology, it appears homogeneously chaotic, the observer alters the level at which he abstracts the information and begins to "average out particulars". A re-examination of Figure 3 tends to support this interpretation. If it were possible to plot physical informational content (in this case, informational content being determined by both NC <u>and</u> PV) on the abscissa, viewing times would be seen to describe an inverted U-shaped function.

Experiment I of Brown and Gregory (in Manuscript) produced results which are also compatible with this type of an interpretation. The procedure used was identical to that used for the FVTG of this study; however, different informational variables were investigated. It was found that there was no difference between viewing times of 4- and 8-sided shapes when the contours were complete; however, for shapes with incomplete contours viewing times decreased from the 4- to the 8-sided shapes. Again, if informational content (dependent in this case upon both the number of sides and the degree of contour completion) were plotted on the abscissa, a decrease in viewing times with increasing information would be evident, suggesting that time spent viewing nonrepresentational patterns begins to fall as the amount of information exceeds some level.

However, it must be remembered that the measure of "task-oriented" information employed in the present study failed to reveal a significant Number of Components X Proximity Variance interaction. An interpretation of the NC X PV interaction in terms of perceived information can therefore be no more than conjectural. Undoubtedly there was much variation as to the strategies by which different individuals approached the matching task, as reflected by the great variability among the individual SEG viewing times. It is possible, for example, that one individual may simply have counted the number of components which the pattern contained, while another might have attended not only to the number of components but also to minute details concerning individual components, as well as to their placement within the pattern.

A rather intensive examination of the Order of Presentation X NC X Curvature interaction failed to reveal any systematic relationship between level of curvature and length of viewing times over the various levels of NC and orders of presentation. Reversals in the tendency toward increasing VT's as a function of increasing NC were found to occur apparently indiscriminantly for both angular and curved patterns and throughout the eight orders of presentation.

One possibility is to attribute this interaction to some complex "novelty" effect, novelty being defined as "a discrepancy between the individual's expectancy about a stimulus and his present perception of that stimulus" (Nusbaum, 1964). As previously stated, each S in the free viewing time situation viewed four practice patterns before viewing the 16 experimental patterns, this being done to reduce the effects of novelty, as the practice patterns had been so selected as to represent all levels of all variables an equal number of times. However, many of the experimental patterns represented new combinations of these variables, and, since it is likely that many Ss soon discovered that the number of possible combinations was far from infinite, the Ss may have become increasingly accurate in their "ecpectancies" as to the nature of subsequent patterns in the experimental series. The nature and extent of the effect on viewing times of such variations in novelty may well have differed from one order of presentation to another.

CHAPTER V

SUMMARY

The purpose of this thesis was to investigate the relationship between human exploratory behavior and several variables which contribute to the informational content of visual stimulus patterns, and to propose an explanation for any possible discrepancy between the two in terms of the processing of information under a "task-oriented" instructional set. In order to investigate this proposition, two experimental situations were utilized: (a) a specific exploratory situation, designed to measure information processing under a "task-oriented" set, in which it was necessary for the S to seek out the informational content of non-representational stimulus patterns in order to perform a subsequent "matching task"; and (b) a "free-viewing" situation, intended as a measure of exploratory activity, in which the S was simply instructed to view a series of non-representational patterns for as long as he "wished".

The informational variables selected for investigation were the number of components making up the pattern, the level of curvature (i.e., angled vs. curved components) of the components, and the variation in the distances between adjacent components (proximity variance).

The free-viewing" situation produced a significant Number of Components X Proximity Variance interaction, and Order of presentation X Number of Components X Curvature interaction, while for the specific exploratory group only the number of components significantly influenced viewing times.

Examination of the Number of Components X Proximity Variance interaction revealed that if informational content were plotted on the abscissa, viewing times would tend to describe an inverted U-shaped function, a result contrary to what would be expected should exploratory behavior more closely follow actual information. However, the failure of the responses of the subjects in the specific exploratory group to reveal any such interaction precludes the interpretation of the "inverted-U" in terms of the processing of information under a "task-oriented" instructional set *as measured by* viewing times under instructions requiring a subsequent match. Therefore, the data were consistent with neither interpretation.

The Order of Presentation X Number of Components X Curvature interaction was discussed in terms of possible complex "novelty" effects.

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