HUMAN EXPLORATORY BEHAVIOR AS A FUNCTION OF INFORMATION ACQUISITION AND DIVERSIONARY ACTIVITY

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CHAPTER I

REVIEW OF THE LITERATURE AND STATEMENT OF THE PROBLEM

Introduction

Berlyne (1960, 1963a, 1965, and 1966) proposes two distinct kinds of exploratory behavior, "Specific" and "Diversive." Specific exploration occurs when the organism is in the kind of motivational condition called "perceptual curiosity." Perceptual curiosity is induced by a lack of information, or subjective uncertainty, as in the case of a brief presentation of a stimulus pattern that does not allow enough time for its characteristics to be identified. Exploratory responses in such a case are directed at obtaining additional stimulation containing the information through which the uncertainty can be removed or reduced. Research (e.g., Berlyne, 1963b) has shown that stimuli high in informational content (i.e., "complex" stimuli), when presented briefly, are chosen more frequently for subsequent examination than stimuli low in informational content (i.e., "simple" stimuli).

Diversive exploration occurs in conditions that are not conducive to perceptual curiosity, as when stimulus patterns are presented long enough for the information contained in them to be extracted. With subjective uncertainty eliminated or reduced, curiosity then plays a minor role. Exploratory responses, in this case, are directed at additional stimulation from any source that possesses collative properties (i.e., properties such as novelty, surprisingness, and complexity) to the "right" or "optimal" degree. Research (Berlyne, 1963b, Hoats, et. al., 1963) has tended to indicate that what is evidently meant by the "right" degree is exposure to stimuli that are less complex.

Thus the properties of stimuli that induce specific exploration are believed to be those that are high in informational content and generally subsumed as complex. The properties of stimuli that induce diversive exploration, however, are held to be those that are less complex and probably termed "attractive" or "pleasing" (Berlyne, 1963a, Berlyne and Peckham, 1966).

Review of the Literature

The literature pertinent to this study can be classified into three main areas: those studies dealing with attempts to quantify the physical properties of visual form, those studies concerned with the relationship between physical parameters and judgements of complexity and pleasingness, and those studies relating the physical parameters of stimuli with human exploratory behavior.

Quantification of Visual Form. The first true attempts at quantifying physical form parameters resulted from the impact of information theory nearly two decades ago. The numerous approaches since then have, according to Michels and Zusne (1965), "... carried quantification beyond the limits of information theory, producing a veritable plethora of physical form measures."

Hochberg and McAlister (1953) found an inverse relationship between response probability (i.e., the probability of a bidimensional perception of Kopfermann cubes) and information load using the number of line segments, angles, and points of intersection of complex line figures as stimulus parameters.

Other physical measures of the amount of information or "complexity" are based on a similar rationale, i.e., that it is the number of elements contained in a stimulus pattern that determines, for the most part, its information load. Attneave (1954) has shown that contours are regions of relatively high informational content. Attneave and Arnoult (1956) showed that information is concentrated at those points in the contour where the change in gradiant is steepest (i.e., verticies, number of sides, etc.). Berlyne (1960, p. 38) suggested "number of distinguishable elements" and "dissimilarity among elements" as parameters underlying complexity.

Brown (1964), drawing largely from the work of Attneave and Arnoult, has compiled a list of stimulus properties by which visual patterns may be described quantitatively. These properties fall into three classifications: (1) component variables -- properties which define unitary shapes or forms, (2) pattern variables -- properties which describe the relations among the components making up a pattern, and (3) arrangement variables -- properties which refer to the various rules by which components may be ordered within a pattern. Included within these classifications are such properties as orientation, proximity of components, angular variance, area, and symmetry.

Michels and Zusne (1965) classified the quantification of physical form parameters into three major types.

> This classification is based on whether changes in the magnitude of the parameter affect the information content (as defined in information theory) or the structure of the shape, or both. Changes in the parameters of one type affect the information content as well as the structure of the shape so radically that they place it in another population

of shapes. This type will be called transitive parameters. The number of inflections in the contour of a shape (i.e., sides or verticies) and the dichotomy of straight versus curved lines in the contour belong here. Changes in another type of parameter do not change either the information content or the structure of the shape, and only the response to the changed shape may be affected since the retinal image of the shape suffers transposition of either location or size, as when a shape is rotated or its area changed. This type of parameter will be called transpositional. Changes in the third type of parameter affect the structure of the shape but not its information content. Thus a triangle is still a triangle regardless of whether it is made thinner or more symmetrical than it was before. This type will be called intransitive.

Relationship of Physical Parameters with judged Complexity and Pleasingness. Attneave (1957) found that 90% of the variance in complexity judgments could be explained by: number of turns, angular variability, the ratio of the perimeter squared over area, and symmetry. Angular or curved shapes were judged to be equally complex; symmetrical shapes were judged to be more complex than asymmetrical ones with the same number of independent turns but less complex when the total number of turns was held constant. Arnoult (1960) obtained similar results, 87% of the variance being accounted for by the number of independent sides, the ratio of the perimeter squared over area, angular variability, and symmetry. Stenson (1966), using factor analysis, found that a single factor accounted for most of the variance in complexity ratings. This factor is best described by four physical measures: the number of turns, the length of the perimeter, the ratio of the perimeter squared over area, and angular variability. With the exception of length of perimeter, these are the same variables found by Attneave (1957) and Arnoult (1960). Arnoult (1957) and, later, Elliott (1958) found the reliability of complexity judgments to be quite high (0.92 and above).

Berlyne has developed a series of stimulus patterns with two absolute levels of complexity, high and low, with varying complexity (i.e., quantity of material, orderliness of arrangement, and incongruity of its members) within each level (Berlyne, 1958a, Berlyne and Lawrence, 1964).

Berlyne (1960, p. 230) reports that when Ss were presented with pairs of stimulus patterns varying in complexity and asked to rate each pattern for "pleasingness" and for "interestingness" there was a significant tendency to attribute more pleasingness to the less complex members of the pairs. The more complex patterns were generally judged as more interesting.

Berlyne and Lawrence (1964) found that Ss rated more irregular (i.e., more complex) figures as less pleasing but more interesting. Berlyne (1963b) had one group of Ss rate stimulus patterns for pleasingness on a seven point rating scale; there was a significant tendency to rate patterns of low complexity as more pleasing. Berlyne and Peckham (1966) used visual patterns varying in complexity as stimuli for three of Osgood's semantic differential scales (Osgood, 1952). Mean ratings on the Evaluative dimension ("ugly"-"beautiful") were significantly different for the low complexity and high complexity patterns. The direction of this difference was essentially the same as indicated by the results cited above (Berlyne, 1963b).

Day (1966a), using Berlyne's stimulus material, found that the proportion of stimuli rated as "liked" was greater for the less complex members of the two absolute levels of complexity.

Terwilliger (1963) presented a method of quantifying the complexity of stimulus patterns based on the proportional areas of the parts of the pattern, the number of different parts, and the number of symmetrical axes in the pattern. Pattern complexity, so defined, was related to judgments of the pleasantness of the patterns. It was found that (a) pleasantness decreases as the absolute magnitude of stimulus complexity increases and (b) pleasantness increases and then decreases as complexity becomes increasingly different from the adaptation level (i.e., the mean complexity value) of all patterns judged.

Day (1966b), with stimuli constructed according to Method 1 of Attneave and Arnoult (1956), examined verbal evaluations of complexity, interestingness, and pleasingness for 4-sided to 160-sided shapes. It was found that complexity tends to rise with variability, i.e., complexity seems to be positively and linearly related to the amount of information contained in the stimulus figures. Both interestingness and pleasingness were said to describe inverted U-shaped functions over varying levels of complexity; however, the extreme variation found for some figures (e.g., 20-sided, 40-sided, and 80-sided) would seem to indicate that factors other than complexity were contributing to the evaluations of pleasingness and interestingness.

Relationship of Physical Parameters to Exploratory Behavior. Berlyne (1957) allowed Ss access to a switch controlling a tachistoscope by means of which they could receive as many successive brief (0.14-sec.) viewings of a pattern as they wished before calling for the next pattern. The results showed that the frequency of response increased progressively over the length of the session and varied directly with the degree of complexity, asymmetry and irregularity of the patterns. The more complex the pattern, the greater the number of times the pattern was viewed. Equivalent results were found by Minton (1963) in a replication of this study. Berlyne (1958a) found that Ss spent more time fixating the more complex member of a pair when stimulus patterns were presented simultaneously for 10 sec. In a supplementary report, with the length of exposure increased to 2 min., Ss again spent more time fixating the more complex member (Berlyne, 1958b). Berlyne (1958c) also found that when stimulus patterns were presented side by side the direction of first fixations in 3- to 9- month-old infants was to the pattern having more internal contour.

Berlyne and Lawrence (1964), allowing Ss to control the length of time a pattern was continuously exposed, found exploration of more irregular figures to be significantly longer with all variables for patterns of low absolute complexity and with one of three variables for patterns of high absolute complexity. In a study using the same procedure (Berlyne and Lewis, 1963), the mean duration of exploration was significantly higher per pattern for the more irregular than for the less irregular patterns. There was no significant difference, however, for patterns of high absolute complexity as was found by Berlyne and Lawrence (1964).

In contrast to the general finding, i.e., that Ss spend more time looking at more complex than at less complex patterns, are the results of a study by Hoats, Miller, and Spitz (1963). Stimulus patterns similar to Berlyne's were used to investigate exploratory choice in a group of retardates, a group of normal children of equal mental age, and normal children of equal chronological age. The Ss were first presented two patterns simultaneously for 3 sec. and then allowed to see either pattern again for as long as they wished. The less irregular patterns were chosen more often than the more irregular patterns by all Ss; however, the degree of preference for low irregular patterns varied among groups. Berlyne (1963b) modified the procedure by using initial exposure-durations of 0.5 sec., 1 sec., 3 sec., or 4 sec. There was a tendency to select more irregular patterns when the initial exposures were 0.5 sec. or 1 sec., and less irregular patterns when initial exposures were 3 sec. or 4 sec. These results were explained in terms of Berlyne's concept of diversive exploratory behavior.

Brown (1966) working within his own system of stimulus specification (Brown, 1964) has attempted to determine more analytically the molar properties (such as complexity) discussed by Berlyne and other workers with regard to viewing time (i.e., duration of exploration). Brown and Farha (1966), from data obtained under three instructional sets, found that patterns with larger areas were viewed longer than patterns with smaller areas under all conditions. For number of turns, however, patterns containing nine-sided shaped were viewed longer under "neutral" and "interestingness" sets, whereas three-sided shapes were viewed longer under a "pleasingness" set. Brown and O'Donnell (1966) found no significant effect for number of turns. They did, however, find that both number of components and angular variance (i.e., the variability of change in contour direction) were variables important to human attention. Analogous data for squirrel monkeys showed only number of components to be significant. Brown and Lucas (1966) found viewing time to be significantly affected by number of components, angular variance and dissimilarity of border width, while number of turns and border width had no significant effect. It is interesting that non-informational variables, such as color (Brown and Farha, 1966) and border width (Brown and Lucas, 1966), were found to have no significant affect on viewing time.

Thus, the studies reviewed have demonstrated, by and large, that it is the informational content of stimuli that affect the various response measures of exploratory behavior.

Statement of the Problem

The purpose of this thesis was to test Berlyne's theory that specific and diversive exploration are differentially controlled by stimulus patterns, i.e., that specific exploratory behavior increases as the amount of stimulus information increases while diversive exploration increases as stimulation approaches some "optimal" level.

This was accomplished by utilizing two experimental situations: first, a specific exploratory situation in which the S was given a task requiring the seeking out (or viewing) of stimuli for their informational content; second, a diversive exploratory situation in which the S was given the opportunity to view the stimuli spontaneously in a boring "waiting room" situation (cf. Berlyne, 1966).

Although it is possible to design a set of patterns varying in informational content, there is no a priori way of knowing which of the patterns come closest to possessing the "right" or optimal amount of such collative properties as novelty, surprisingness, etc. It was therefore necessary to begin by designing a set of patterns varying in informational content and, before putting these in the two experimental situations, determining the extent to which they possessed the right collative properties. Although Berlyne is not precise as to what is meant by right or optimal collative properties (since he frequently employs a circular definition based on the amount of exploratory behavior directed at stimuli), an examination of his theory (Berlyne, 1963a) suggested that stimulus patterns possessing optimal collative properties were also those patterns judged or perceived to be "attractive." The first stage of this study therefore involved a determination of the patterns' rated "attractiveness."

To lend support to Berlyne's theory, the Specific Exploratory Group (SEG) should have shown longer viewing times for the stimulus patterns high in formational content, while the Diversive Exploratory Group (DEG) should have shown longer viewing times for those stimulus patterns judged to be "attractive."

CHAPTER II

METHOD

Subjects

Each of 264 undergraduate volunteers enrolled in introductory psychology courses at Oklahoma State University was assigned to one of three groups. One hundred four Ss rated the stimulus patterns for "attractiveness," 80 Ss were in the SEG, and 80 Ss served in the DEG. An equal number of male and female Ss was used in all groups.

Stimulus Patterns

Sixteen stimulus patterns, each representing one cell in a 4 X 2 X 2 factorial design, were prepared. The three factors were number of components, proximity of variance, and curvature.

Number of components (NC) refers to the number of shapes which make up a pattern. The four levels of NC were 3, 6, 12, and 24. The shapes were three eight-sided polygons constructed according to Method 1 and Method 4 of Attneave and Arnoult (1956). Method 1 consists of contructing 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.

The completed shapes, three angular and three curved, were photographically reduced or enlarged so that all shapes were a constant area of 200 $mm.^2$

Proximity of variance (PV) refers to the variance of the distances between adjacent shapes. The two levels of PV were high (a mean value of 6.23 cm.) and low (0 cm.).

The patterns were constructed, with slight modifications, according to the method described by Brown (1966). This method consisted of first preparing a prototype of the 24-component pattern and then systematically deriving the 12-, 6-, and 3-component patterns from this prototype. To prepare the 24-component pattern prototype, a 25-X25-cm. grid was laid out on graph paper and 24 cells were chosen by means of a table of random numbers. Measurements of the distances between "adjacent" cells (measured from each cell to the cell nearest it) were made, with the mean and variance of these distances being computed. The mean distance was 2.2 cm., and the variance (PV) was 6.06 cm. The 12-, 6-, and 3-

component patterns were designed using cells found in the 24-component pattern, with the stipulation that their means and PVs be as close to that of the 24-component pattern as possible. For these patterns the mean distance and PV ranged from 1.8 cm. to 2.27 cm., and from 6.12 to 6.48, respectively. These patterns were designated as the high-PV patterns.

For construction of the low-PV patterns a 24-component pattern prototype was again prepared, following the procedure described above, but the cells were selected (by random numbers) with the restriction that no "adjacent" cells should have a distance of less than 2 cm. separating them. With this restriction it was possible to obtain a 24-component pattern with a mean distance of 2.0 cm. and PV of 0. The 12-, 6-, and 3-component patterns were then obtained in the same manner as those for the high-PV patterns. The mean distance for the low-PV patterns was thus 2.0 cm., with a PV of 0.

The shapes, described above, were applied to the patterns in the following manner: the three angular shapes were randomly assigned to a pattern with the restriction than an equal number of each shape appear on a given pattern. Once a shape was assigned a cell it occupied that cell in all other patterns with the same PV which had that cell as a component. Curved shapes were placed in the same locations as the angular shapes from which they were derived.

All shapes were placed in a vertical orientation (see Brown, 1964). Since the shapes had an area of 200 $mm.^2$ and the cells to which they were assigned were only 100 $mm.^2$, each shape was drawn on a pattern by centering it by eye on its respective cell.

The 16 patterns were prepared for photography by placing each over heavy white vellum paper and, using a sharp pin, making small indentations at the contours from every shape in the pattern. The white paper was then cut to size (25- X 25-cm.) and the shapes, cut from heavy black construction paper, were cemented to the white paper using the indentations of the contours as guides. The patterns were then photographed and prepared both as 2- X 2-in. slides and 25- X 25-cm. prints. The shapes appeared black against a transparent background for the slides, and black against a white background for the prints.

Apparatus

A Kodak Cavalcade slide projector was used for presentation of the stimulus patterns for the judgemental task. A booklet was prepared for each S, constructed so that each stimulus pattern would be rated on a separate sheet of paper. This booklet consisted of 17 8½- X 3½-in. pages. The first page contained the instructions and a sample rating scale. The remaining pages, numbered from 1 to 16, contained the rating scale only. The rating scale contained seven categories: "Extremely Unattractive," "Quite Unattractive," "Slightly Unattractive," "Neither Unattractive Nor Attractive," "Slightly Attractive," "Quite Attractive," and "Extremely Attractive."

The apparatus for the SEG was, in part, that used by Brown and O'Donnell (1966):

> The apparatus included a heavy wooden screen measuring 7 ft. wide and 5 ft. high and painted flat black, in which there was a 25- X 25-cm. window covered with tightly stretched tracing paper. The base of the window was 3½ ft. from the floor. Behind the screen an elevated slide projector (Airquip Superba 77) was directed at the window and positioned so that the projected patterns had the same spatial dimensions as those originally drawn. The slides were placed in the projector so that, when viewed from the front of the screen, the patterns appeared in the same orientation as the originals. The projector was equipped with a

solenoid-operated shutter.

A chair with a telegraph-key attached to the arm was placed 4 ft. before the front side of the screen facing the window. The telegraph-key, shutter, and projector were so connected with a Marietta interval-timer that pressure on the key served to (a) close the shutter, (b) advance the slide magazine of the projector, and (c) reopen the shutter. Included also in the system was an Esterline-Angus event recorder which recorded the opening and closing of the shutter-mechanism.

A Wollensak Alphax automatic shutter, set for 1 sec., was mounted in a 4- X 4-ft. black plywood shield. This shield was placed on a table, 30 in. in height, positioned immediately to the right of the chair described above. On the wall 5 ft. behind the shield was a 4- X 4-ft. white vertical surface upon which the 16 stimulus patterns could be variously positioned by means of "picture hangers" in four columns and four rows. Attached to the black plywood shield was a 40- X 30-in. sheet of black posterboard positioned in such a way that the vertical surface on the wall behind the shield could not be seen either from the chair or upon entering the room.

The experimental room had no windows except one in the door which was covered with black cloth. The apparatus was so arranged that on entering the room the Ss saw only the front side of the screen, the shutter-mechanism mounted in the black shield, and the chair with its telegraph-key.

The Ss of the DEG were observed in a 6- X 9-ft. room painted flat black and containing a one-way mirror. Beyond the one-way mirror was a sound-proof observation room with a separate entrance. The one-way mirror was concealed with black posterboard in which were two 3- X 2-in. viewing holes. The viewing holes were disguised by two "lights" attached to the mirror and surrounded by black mesh to eliminate reflections from the room. Directly in front of, and 3 ft. from, the "light panel" was an arm chair with a telegraph-key attached. Subjects were not aware that the "lights" and telegraph-key were dummies, as wires from both led into the observation room but were not connected to an outlet or any apparatus. Also in the experimental room, behind and to the left of the "experimental chair," was a table upon which was a "book" containing the stimulus patterns. In addition to the "book" the table held four scientific reprints of little interest to introductory psychology students. An ashtray on the table and a molded plastic chair next to the table gave that portion of the room a rather casual, non-experimental appearance. The chair along with the table and its contents were in full view from the viewing ports.

A Stolting electric timer, calibrated in hundredths of a second, was located in the observation room.

Procedure

For the rating the stimulus patterns were displayed by projecting them individually on a screen on the front wall of the room in which Ss were seated. Each S was provided with a rating booklet. The instructions given contained no definition, either explicit or implicit, of the terms "Attractive" and "Unattractive."

Before making their ratings the Ss were shown all 16 patterns in rapid succession (4-sec. exposure each) in order that they might adapt their rating behavior to the range of stimuli to be presented. In displaying the patterns for rating each was exposed for 16 sec. with a negligible inter-exposure interval.

The Ss served in four groups of 26 each. The sequence used for the first group was a random permutation of the 16 stimuli, that for the second was an "inside-out" reordering of the first, and those for the third and fourth groups were reversals of the first two sequences.

The procedure for the SEG consisted of three phases: (a) a brief viewing of all 16 stimulus patterns, (b) the examination of one stimulus pattern, and (c) the subsequent matching of the examined pattern with one of the 16 patterns viewed briefly.

In the first phase Ss were shown all 16 stimulus patterns mounted on the white vertical surface behind the shield by means of the shutter described above. The instructions were as follows:

I am going to briefly show you some patterns on the wall behind this shield which you will use in a later task. I want you to place one eye as close to the shutter as you can. Keep the other eye closed and look straight at the shutter. When I open the shutter I want you to scan the patterns very quickly so as to see as much as you can during the brief exposure. Just try to see as much as you can during the time allowed. Are there any questions?

At appropriate points in the instructions the experimentor (E) pointed out the wall behind the shield and the shutter.

When the S was correctly positioned the shutter was opened by the E for two 1-sec. exposures with an interval of 2 sec. between exposures.

After the exposure the following instructions were given 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. Remember, look at the pattern only for as long as you think is necessary to make a correct match. Are there any questions?

Again, at appropriate points in the instructions the E pointed out the location of the screen and the telegraph-key.

After the S was ready, the E turned on the projector lamp and the event recorder and told the S to "start." When the S had pressed the telegraph-key for the second time (turning the pattern off) the E turned off the projector lamp and the event recorder. These instructions were then given the S:

I now want you to come around behind this shield and pick out the pattern you just looked at. When you have made your selection please point to the pattern of your choice. Are there any questions?

When the S had made his choice the E recorded the position number of the pattern (on the vertical surface) along side the S's name and the number of the pattern examined.

Five Ss were given the same pattern to examine, thus requiring 80 Ss for the 16 stimulus patterns. In the process of obtaining the necessary 80 Ss 22 volunteers were eliminated for failure to make a correct match.

To control for any effect of pattern position during the brief viewing phase, the 16 stimulus patterns were randomly assigned to the 16 positions on the vertical surface. Five separate randomizations were used, with the positions of the patterns being changed after every 16th S.

For the DEG the stimulus patterns (i.e., the 25- X 25-cm. photographic prints) were attached to 27- X 25-cm. white vellum paper square and assembled in a "book" by means of two metal rings placed through holes punched in the non-print portion of the pages. The cover of this book contained the words "ESP Patterns" in 3/4-in. red letters outlined in black. Below the title was the statement "For best effect view these patterns in order" in ¼-in. black print. The book, containing the cover and five stimulus patterns, was placed prominently on the table described above.

When a S in the DEG arrived at the laboratory he was ushered into the experimental room and asked to sit in the molded chair described above. The S was told to "relax" and that "it will take about 5 to 10 min. to put a new timing sequence into the programmer and calibrate the apparatus." The E then closed the door and retired to the observation room where he took a position by the viewing ports to observe the S's activity.

To serve as a S it was necessary for the volunteer to pick up the stimulus pattern book and examine the first pattern within 5 min; a pilot study, with Ss left in the experimental room for as long as 15 min., indicated that those Ss who would spontaneously examine the book would do so within the first 5 min.

When a S picked up the book and opened it to the first page the electric timer, described above, was started. The timer was stopped when the first page was turned or the book closed.

One minute after the book was closed, or after 5 min. if it was not examined, the E reentered the experimental room. The S was instructed to sit in the chair with the telegraph-key and told that this was an experiment in subliminal perception and to press the key whenever he saw a light. The S was told that the lights would be presented randomly and below threshold and that he might not see every flash but to press the key twice for the left light and once for the right light. The E then retired from the room, returning in 2½ min. to excuse and thank the S for participating.

The first pattern in the book was the only pattern timed, and then only for the initial examination. This pattern was presented to five Ss and then replaced with a new pattern. Thus, as in the SEG, 80 Ss were required for the 16 stimulus patterns. Also as in the SEG, the distribution of male and female Ss was equalized. In the process of obtaining the 80 Ss 73 volunteers were eliminated for failure to examine the book and/or the first pattern within 5 min.

CHAPTER III

RESULTS

Ratings of Attractiveness

The ratings for each stimulus pattern were scaled according to Condition D of the "law of categorical judgment" (Torgerson, 1958 p. 236). The resulting scale values (presented in Appendix A) suggested that for these Ss the category widths were equal, since a plot of each scale value against its mean category value (see Appendix B) revealed a linear relation. Thus, the rating data were analyzed by means of an analysis of variance (AOV).

The data were arranged in a 4 X 2 X 4 X 2 X 2 factorial design, the first two factors were presentation sequence (Sq) and sex (Sx); the last three factors were the three stimulus factors.

Since the assumptions underlying the repeated-measures design (i.e., homogeneity and symmetry of variance-covariance matrices) were untested, the critical values for the F-ratios of the within-Ss effects were the adjusted degrees of freedom for the Conservative test recommended by Greenhouse and Geiser (1959).

The results of the AOV, presented in Table I, revealed NC, PV, NC X PV, NC X Cv, and PV X Sx to be significant sources of variance contributing to the "attractiveness" ratings of the stimulus patterns.

TABLE I

SUMMARY OF ANALYSIS OF VARIANCE FOR RATING DATA

SOURCE	df	SS	MS	F
BETWEEN SUBJECTS	103	675.5569	6.5588	-
Sequence (Sq)	3	32.7903	10.9301	1.69 NS
Sex (Sx)	1	1.9525	1.9525	<1 NS
Sq X Sx	3	18.5932	6.1977	<1 NS
Ss w. Sq X Sx	96	622.2209	6.4815	-
WITHIN SUBJECTS	1560	3300.4222	2.1157	-
Number of Components (NC)	3	65.0883	21.6961	5.22 *
NC X Sq	9	75.7795	8.4199	2.02 NS
NC X Sx	3	4.3720	1.4573	<1 NS
NC X Sq X Sx	9	62.1304	6.9034	1.66 NS
NC X Ss w. Sq X Sx	288	1197.8155	4.1591	-
Proximity of Variance (PV)	1	133.3179	133.3179	47.30 **
PV X Sq	3	2.4970	0.8323	<1 NS
PV X Sx	1	31.5150	31.5150	11.18 **
PV X Sq X Sx	3	1.3768	0.4589	<1 NS
PV X Ss w. Sq X Sx	96	270.6058	2.8188	-
Curvature (Cv)	1	0.9141	0.9141	<1 NS
Cv X Sq	3	1.8624	0.6208	<1 NS
Cv X Sx	1	0.0054	0.0054	<1 NS
Cv X Sq X Sx	3	25.2710	8.4237	2.24 NS
Cv X Ss w. Sq X Sx	96	361.5093	3.7657	-

TABLE I (CONTINUED)

SOURCE	df	SS	MS	F
NC X PV	3	29.9105	9.9702	8.61 **
NC X PV X Sq	9	12.8611	1.4290	1.23 NS
NC X PV X Sx	3	4.1749	1.3916	1.20 NS
NC X PV X Sq X Sx	9	3.8275	0.4253	< 1 NS
NC X PV X Ss w. Sq X Sx	288	333.6583	1.1585	-
NC X Cv	3	12.7085	4.2362	4.40 *
NC X Cv X Sq	9	17.3708	1.9301	2.00 NS
NC X Cv X Sx	3	0.8672	0.2891	< 1 NS
NC X Cv X Sq X Sx	9	14.7890	1.6432	1.71 NS
NC X Cv X Ss w. Sq X Sx	288	277.4472	0.9634	-
PV X Cv	1	1.6881	1.6881	1.64 NS
PV X Cv X Sq	3	7.9922	2.6641	2.58 NS
PV X Cv X Sx	1	0.5775	0.5775	< 1 NS
PV X Cv X Sq X Sx	3	0.9297	0.3099	< 1 NS
PV X Cv X Ss w. Sq X Sx	96	99.1242	1.0325	-
NC X PV X Cv	3	6.2422	2.0807	2.66 NS
NC X PV X Cv X Sq	9	6.3179	0.7020	< 1 NS
NC X PV X Cv X Sx	3	0.1797	0.0599	< 1 NS
NC X PV X Cv X Sq X Sx	9	10.0880	1.1209	1.43 NS
NC X PV X Cv X Ss w. Sq X Sx	288	225.6072	0.7834	-
TOTAL	1663	3975.9791	2.3909	-

TABLE I (CONTINUED)

CONSERVATIVE TEST

* $F_{(1,96)}$= 3.96, P= .05	** $F_{(1,96)}$= 6.96, P= .01
* $F_{(3,96)}$= 2.72, P= .05	** $F_{(3,96)}$= 4.04, P= .01

TREND ANALYSIS

ORDERED VARIABLE	df	SS	MS	F
NC_L	1	7.3328	7.3328	$<$ 1 NS
NC_Q	1	50.8898	50.8898	5.37 *
NC_C	1	6.8655	6.8655	$<$ 1 NS
NC	3	65.0833	21.6961	-

* $F_{(1,192)}$= 3.91, P= .05

These results can best be understood by examining the profiles for the simple effects.

Figure 1 (the NC X PV interaction) shows patterns of low PV as having higher mean ratings across all levels of NC than patterns of high PV. However, the 12-component patterns received the highest mean rating among the low PV patterns, while the 6-component patterns received the highest mean rating among the high PV patterns. Both levels of PV, however, describe somewhat of an inverted U-shaped function in relation to increasing complexity (i.e., increasing NC).

A plot of the NC X Cv interaction (Figure 2) reveals a similar inverted U-shaped function for the two levels of Cv across NC. Angled stimulus patterns received highest mean ratings at the three lowest levels of NC, whereas curved patterns received highest ratings at intermediate levels of NC.

Figure 3 (the PV X Sx interaction) shows that while the ratings of patterns both male and female Ss decreased with increasing PV, female Ss rated low-PV patterns higher, and high-PV patterns lower, than did male Ss.

An orthogonal polynomial analysis for trend on NC, the levels of which represent equal geometric steps along a psychological continuum of complexity, revealed only the quadratic component to be significant (see Table I). Thus, a curvilinear function best describes the effect of NC on rated "attractiveness."

Specific Exploratory Behavior

Five viewing times (VT's), each measured to the nearest quarter of a second, were recorded for each stimulus pattern in the SEG. Because a plot of the data revealed marked positive skewness, a logarithmic transformation of the raw data was used to normalize the distribution and to increase homogeneity of variance (Winer, 1962 Pp. 218-222). The transformed VT's were analyzed by means of an AOV, with the data arranged in a 4 X 2 X 2 factorial design. The results of this AOV (see Table II) show no main effects or interactions to be significant. Number of

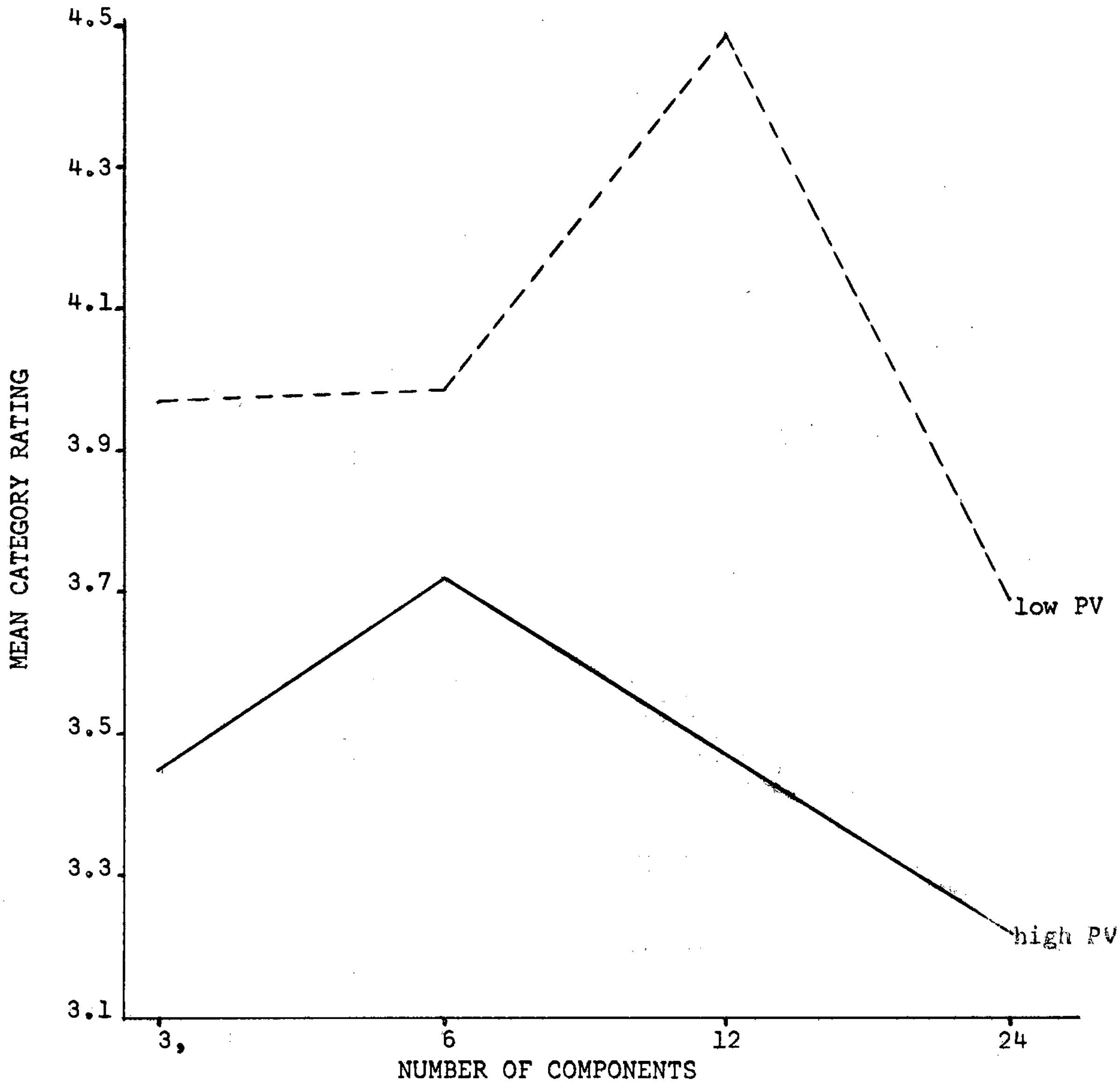

Figure 1. NC X PV INTERACTION

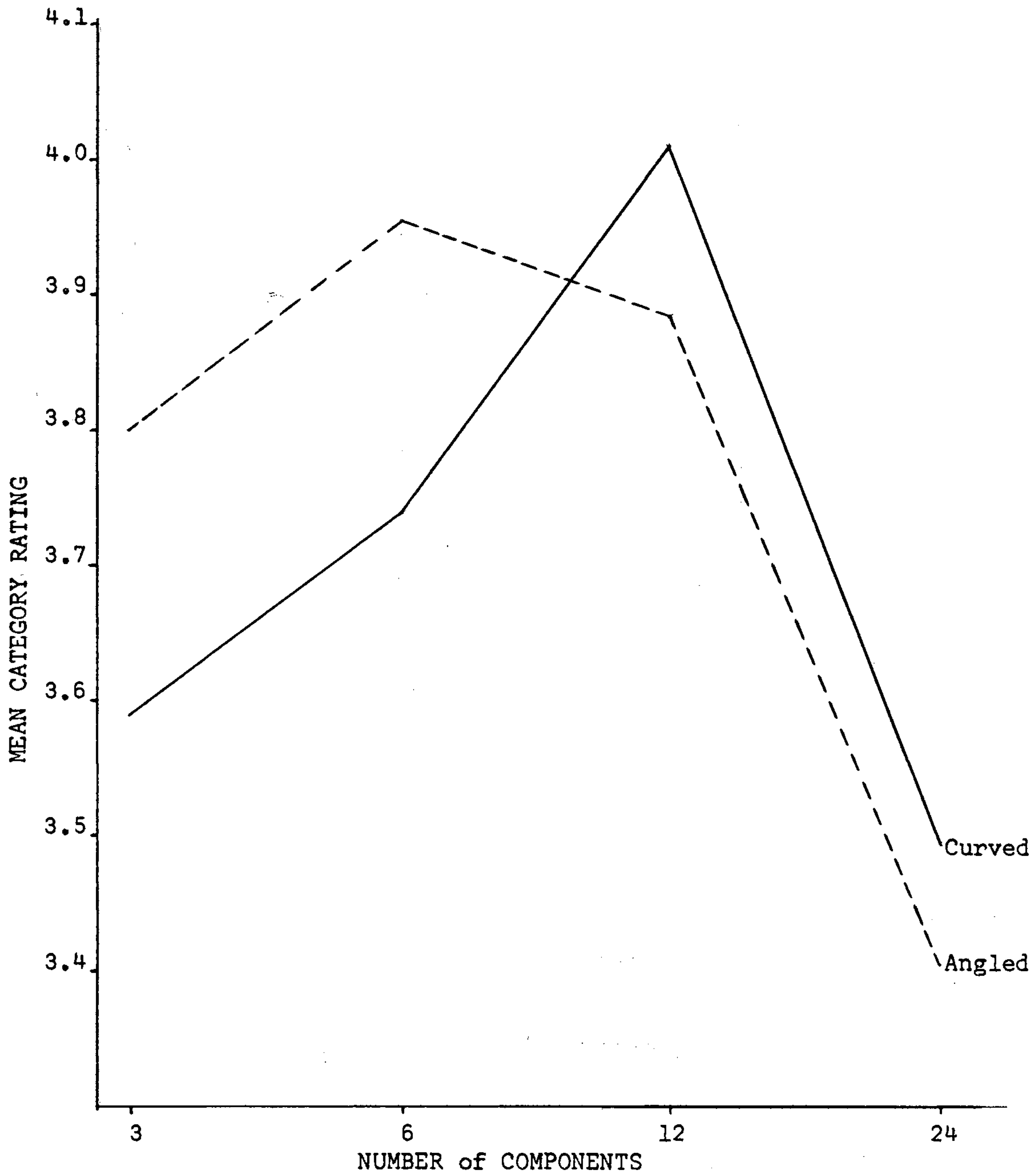

Figure 2. NC X Cv INTERACTION

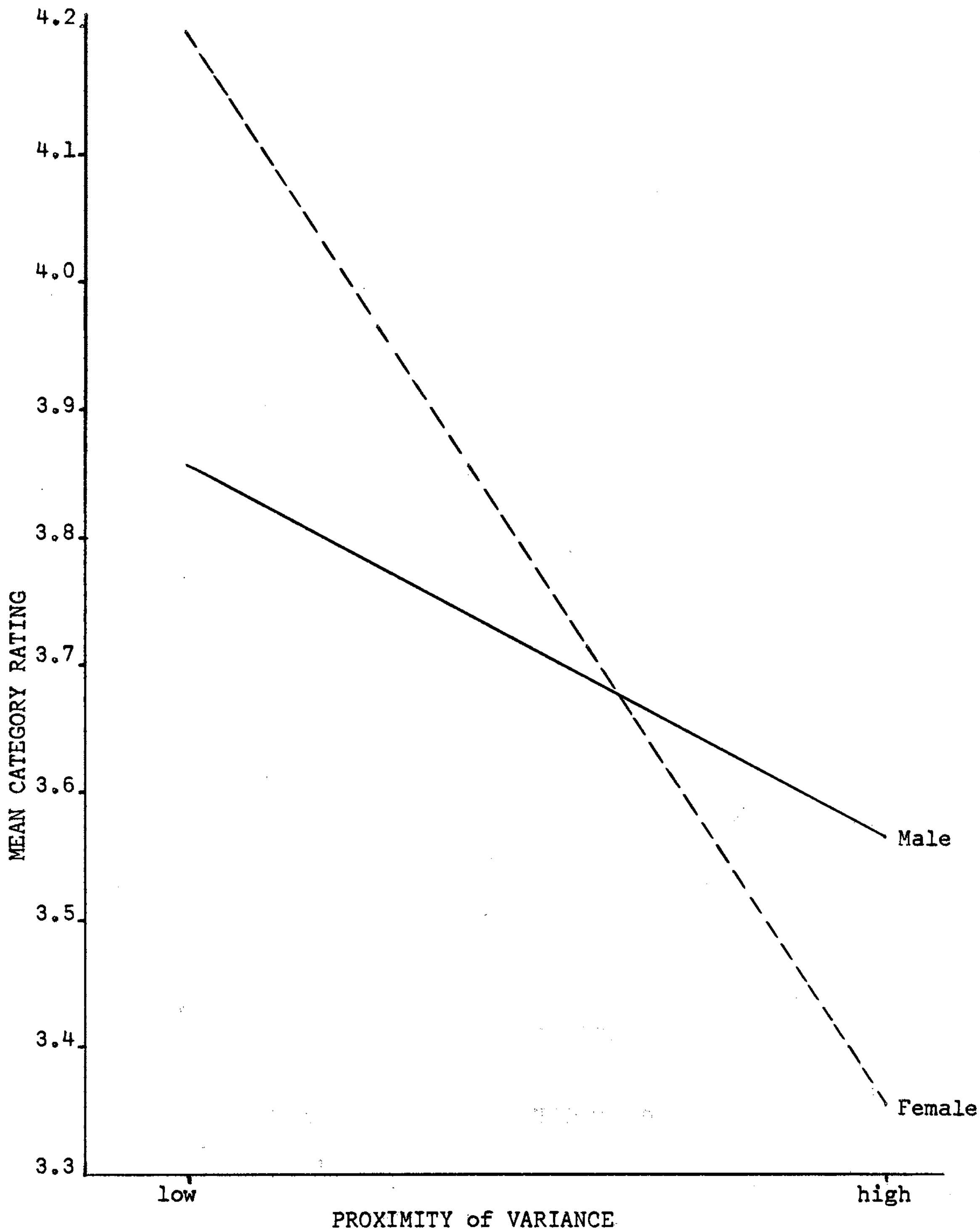

Figure 3. PV X Sx INTERACTION

components, however, approaches significance (F=2.34, df=3/64, P <.10). An orthogonal polynomial analysis for trend on NC showed the linear component to be significant (see Table II and Figure 4).

A comparison by means of a t test of the mean VT's for males (M=7.76 sec.) and females (M=12.57 sec.) within the SEG revealed a significant difference (t'=3.09, df=39, P <.01 with a two-tailed test). Unequal group variances (F=2.11, df=39/39, P <.01) necessitated the use of the t' distribution for this test (Cochran and Cox, 1957, p. 101).

Diversive Exploratory Behavior

For the DEG, five VT's, each measured to the nearest one hundredth of a second, were recorded for each stimulus pattern. As in the SEG, the raw data showed a marked positive skewness; therefore, a logarithmic transformation was used on the data. The transformed data were analyzed by means of an AOV, with the data arranged in a 4 X 2 X 2 factorial design. From the results of this analysis, presented in Table III, it can be seen that no main effects or interactions reached significance; further, a trend analysis on NC failed to reveal any significant components.

Since it was hypothesized that VT would be longer for stimulus patterns rated as more "attractive," a comparison was made between the mean VT of the highest rated pattern (12-component, low-PV, curved) and that of the lowest rated pattern (24-component, high-PV, curved). A t test revealed no significant difference between the two means (M=6.30 sec. and M=3.31 sec., respectively, t=1.35, df=8, P >.20).

Although there were no significant differences among the mean VT's for the DEG, a plot of these times against increasing levels of NC (see Figure 4) revealed no trend for the means to be in the direction

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE FOR SEG

SOURCE	df	SS	MS	F
Number of Components (NC)	3	0.732	0.244	2.24 NS
Proximity of Variance (PV)	1	0.075	0.075	0.69 NS
NC X PV	3	0.006	0.002	0.02 NS
Curvature (Cv)	1	0.004	0.004	0.04 NS
NC X Cv	3	0.274	0.091	0.84 NS
PV X Cv	1	0.084	0.084	0.77 NS
NC X PV X Cv	3	0.253	0.084	0.77 NS
WITHIN CELLS	64	6.952	0.109	-
TOTAL	79	8.380	0.106	-

TREND ANALYSIS

ORDERED VARIABLE	df	SS	MS	F
NC_L	1	0.71875	0.71875	6.62 *
NC_Q	1	0.01267	0.01267	$<$ 1 NS
NC_C	1	0.00056	0.00056	$<$ 1 NS
NC	3	0.73198	0.24399	-

* $F_{(1,64)} = 4.00$, P= .05

$F_{(3,64)} = 2.76$, P= .05

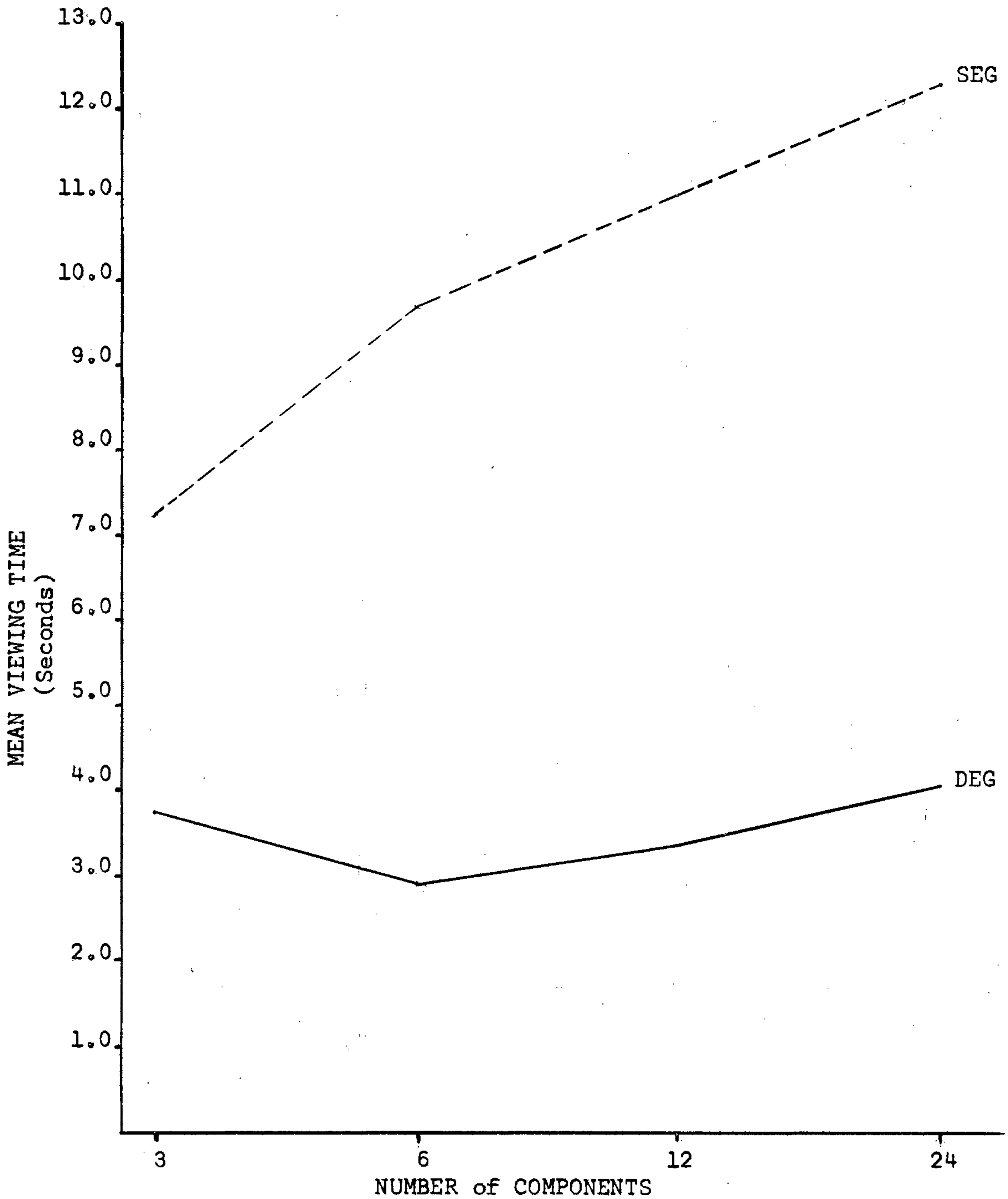

Figure 4. MEAN VIEWING TIMES OF SEG AND DEG

TABLE III

SUMMARY OF ANALYSIS OF VARIANCE FOR DEG

SOURCE	df	SS	MS	F
Number of Components (NC)	3	0.039	0.013	0.14 NS
Proximity of Variance (PV)	1	0.005	0.005	0.05 NS
NC X PV	3	0.362	0.121	1.32 NS
Curvature (Cv)	1	0.010	0.010	0.11 NS
NC X Cv	3	0.496	0.165	1.79 NS
PV X Cv	1	0.049	0.049	0.53 NS
NC X PV X Cv	3	0.505	0.168	1.83 NS
WITHIN CELLS	64	5.859	0.092	-
TOTAL	79	7.323	0.093	-

TREND ANALYSIS

ORDERED VARIABLE	df	SS	MS	F
NC_L	1	0.00055	0.00055	<1 NS
NC_Q	1	0.00060	0.00060	<1 NS
NC_C	1	0.03744	0.03744	<1 NS
NC	3	0.03859	0.03859	-

$F_{(1,64)} = 4.00$, P= .05

$F_{(3,64)} = 2.76$, P= .05

predicted by Berlyne (1963b, 1966).

The mean VT of the SEG (10.16 sec.) was found by means of a *t* test to be significantly longer than the mean VT for the DEG (3.65 sec.; $t'=7.29$, $df=79$, $P<.01$ for a two-tailed test). The variances of the two groups were significantly different ($F=5.17$, $df=79/79$, $P<.05$), necessitating the use of the t' distribution.

CHAPTER IV

DISCUSSION

The physical parameters found to significantly affect the rated "attractiveness" of a stimulus pattern, number of components and proximity of variance, are informational variables. These variables, following the classification of Michels and Zusne (1965) would be termed "transitive" parameters, since a change in either variable would affect the informational content of a stimulus pattern. It would seem to follow, therefore, that rated "attractiveness" is in part a function of the informational content of a stimulus pattern.

The finding of an overall inverted U-shaped function relating rated "attractiveness" to increasing levels of information lends support both to the position taken by Berlyne (e.g., 1963a) and to the findings of Day (1966b).

The finding that curvature, also an informational variable, was significant only in interaction with number of components would seem to imply that curvature plays only a minor role in determining the "attractiveness" of a pattern. This may be due, in part, to the fact that curvature contributes little to the "phenomenal" complexity (cf. Heckhausen, 1964) of a stimulus pattern, Attneave (1957) having shown that curved and angled shapes are judged as equally complex.

The hypothesis that specific exploratory behavior increases as the amount of stimulus information increases was supported, although weakly at best. The finding that number of components only approached significance was unexpected, since this variable has been previously shown to be a factor of importance in human attention (Brown and O'Donnell, 1966). It has also been shown that scanning movements are largely confined to the contours of shapes (Zusne and Michels, 1964) and, since the correlation between number of components and the amount of contour present in a pattern is a positive one, a positive relationship between viewing time and number of components would have been predicted. The lack of significance found for number of components would seem to be primarily a result of both the small sample of Ss who viewed each pattern and the extreme heterogeneity of the viewing times within each sample. The non-significance of proximity of variance and curvature may be evidence that these are not variables of attentional importance.

The finding that females viewed the stimulus patterns significantly longer than males appears puzzling. Two possible explanations, however, may be ventured: (a) Females are more cautious, and, hence, tend to spend more time viewing the patterns so as to lessen the probability of errors in making their matches, or (b) males are able to process the information contained in a stimulus pattern at a faster rate than females. The former argument seems less likely, since nearly an equal number of males and females (12 and 10, respectively) made incorrect matches.

The lack of conclusive results from the diversive exploratory group would seem to be, as in the specific exploratory group, mainly a function of a small sample employed for each stimulus pattern and the wide variation of viewing times within each sample. It may be that the range of stimulus patterns presented did not provide enough interest to the Ss to warrant any prolonged examination. That is, with no specific instructions to view the stimuli the <u>general</u> nature of each stimulus pattern may have been perceived very quickly. This would seem to explain the finding that the viewing time for the diversive exploratory group was significantly less than that for the specific exploratory group. This finding would seem contrary to the results reported by Murray (1966), however, for in that study the "natural" viewers were also under no specific instructions to view the stimuli.

The finding that the relation between exploratory behavior and number of components, although not significant, tended to be in a direction opposite to that predicted by Berlyne (e.g., 1963b), is open to a number of interpretations. It may, for instance, simply be due to inadequate sampling or, it might be that for some unknown reason the 3- and 24-component stimulus patterns contained the "optimal" collative properties necessary to induce diversive exploration. It is also possible, however, that in a truly diversive situation, as was presented here, viewing time may not be a function of the "attractiveness" of the stimulus patterns, but, rather, a function of their "interestingness." This latter argument would seem a more likely explanation, since it has been shown that viewing behavior under "neutral" instructions tends to be more positively related to behavior under "interestingness" instructions than to that under "pleasingness" instructions (Brown and Farha, 1966). It should be noted that Berlyne, while primarily espousing the importance of stimulus pleasingness or attractiveness to diversive exploration, has also stated that the stimuli must provide the right degree of "interest" (1963a, p. 290).

CHAPTER V

SUMMARY

The purpose of this thesis was to test D. E. Berlyne's theory that specific and diversive exploration are under differential stimulus control, i.e., that specific exploratory behavior increases as the amount of stimulus information increases while diversive exploration increases as stimulation approaches some "optimal" level.

Two experimental situations were utilized: (a) a specific exploratory situation in which 80 Ss were given a task requiring the viewing of nonrepresentational stimuli for their informational content, and (b) a diversive exploratory situation in which 80 Ss were given the opportunity to view the same nonrepresentational stimuli spontaneously in a boring "waiting-room" situation.

An additional problem involved the determination of the rated "attractiveness" of the stimulus patterns. ("Attractiveness" was assumed to correspond to what Berlyne means by the term "optimal" level). This was accomplished by having 104 Ss rate each stimulus pattern on a seven point scale of "attractiveness."

The major findings were: (1) Rated attractiveness described an inverted U-shaped function over varying levels of information (i.e., complexity). (2) The number of components and the variance of the distances between adjacent components, both informational variables, contributed significantly to the rated attractiveness of the patterns.

(3) Curvature, also an informational variable, was significant only in interaction with number of components. (4) An interaction between the sex of the S and proximity variance was significant, with females rating the low-variance patterns higher in attractiveness and the high-variance patterns lower than males. (5) Support for the hypothesis that specific exploratory behavior increases as the amount of stimulus information increases was found, although the evidence was far from definitive. (6) Females in the specific exploratory situation viewed the stimuli significantly longer than the males. (7) The mean viewing time in the specific exploratory situation was significantly longer than that in the diversive exploratory situation. (8) No significant evidence was found for the hypothesis concerning diversive exploratory behavior; however, the direction of the results was opposite to that predicted by Berlyne.

The later was discussed in terms of previous research, and it was suggested that "interestingness" rather than "attractiveness" is the "optimal" stimulus property necessary for diversive exploratory behavior.

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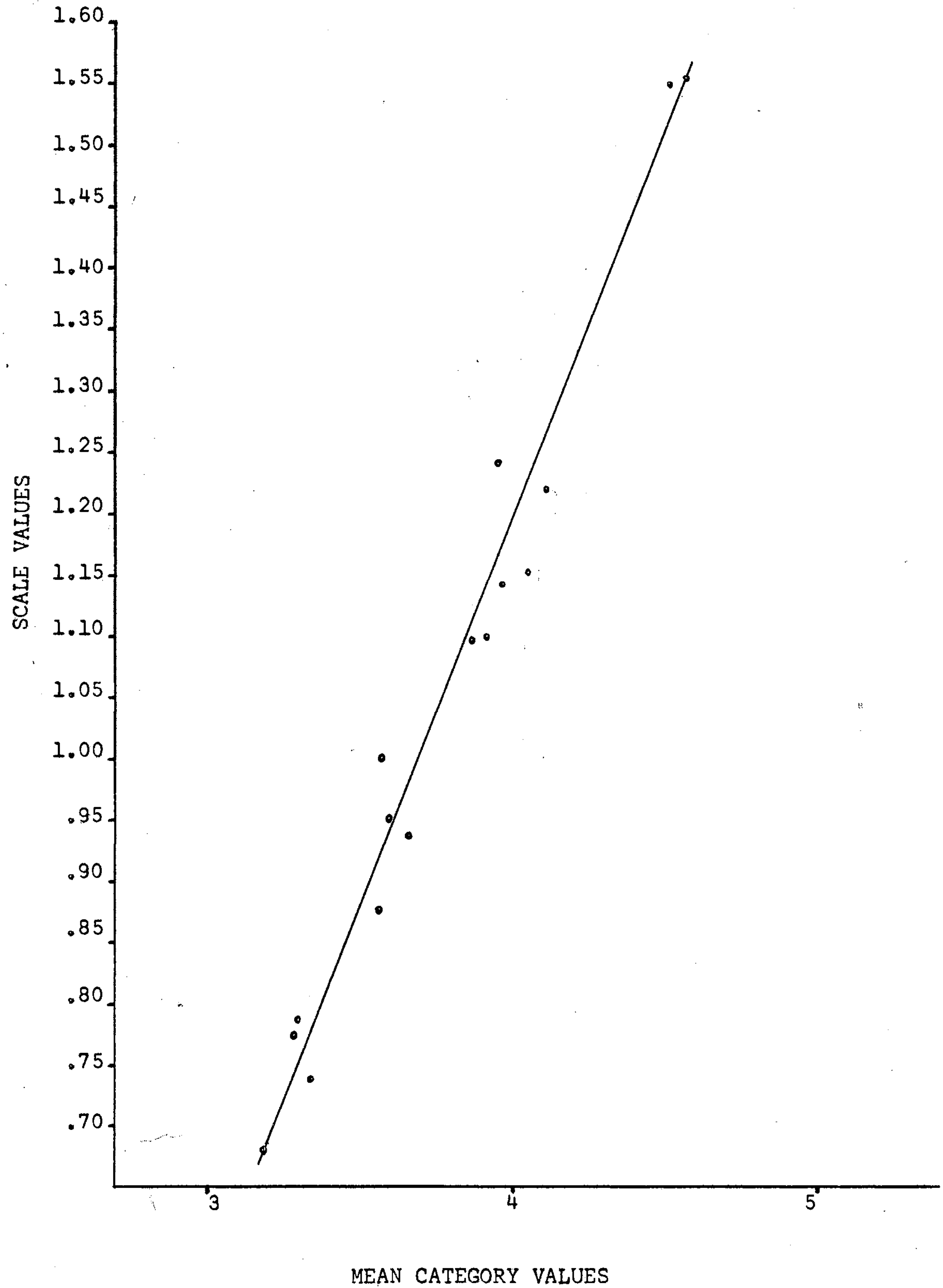
APPENDIX A

COMPUTED SCALE VALUES

NUMBER OF COMPONENTS	LOW-PV		HIGH-PV	
	ANGLED	CURVED	ANGLED	CURVED
3	1.151	1.099	0.952	0.786
6	1.222	1.142	1.241	0.874
12	1.549	1.554	0.737	0.937
24	0.997	1.097	0.771	0.677

APPENDIX B

SCALE VALUE AS A FUNCTION OF CATEGORY VALUE



VITA

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