THE END-SEGREGATION EFFECT IN TACHISTOSCOPIC PERCEPTION OF BINARY PATTERNS

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Peter Michael Monti

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Peter Michael Monti

Approved, May 1971

E. Rae Harcum, Ph.D.

F. Samuel Bauer, M.A.

Peter L. Derks, Ph.D.

Herbert Friedman, Ph.D.

John F. Lavach, Ed.D.

Stanley B. Williams, Chairman
Department of Psychology

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ABSTRACT

Mnemonic factors, such as primacy and end-segregation have been suggested as important mechanisms in the determination of response distributions when binary patterns are tachistoscopically flashed before an _S_. The primary purpose of the present research is to analyze the end-segregation effect--the tendency for _S_ to reproduce more accurately those elements which appear in the more extreme positions. In Exp. I the length of the binary patterns (from 4 to 28 elements) and their order of presentation was manipulated. It was predicted that there would be no end-segregation for the shortest and longest patterns, and that there would be greater end-segregation for patterns of intermediate length. Results supported the predictions except that the 4-element pattern produced end-segregation. It was also expected that there would be fewer errors on those presentations in which the _S_ knew the length of the pattern before exposure. There was no such effect of knowledge of pattern length, however.

Exp. II studied whether or not the extreme positions of elements in the patterns used in Exp. I could be reproduced accurately when presented without the intervening elements. Since they could be reproduced accurately, they were within the range of effective vision.

Exp. III was designed to investigate an apparent conflict in the results of Exp. I, which showed no effects of foveal facilitation (_i. e._, fewer errors for those elements appearing about fixation). Such a phenomenon has been noted in much previous research. Previous studies used a center marker on the response template, whereas no center marker was used in Exp. I. Exp. III employed the 28-element patterns used in Exp. I and a small marker which bisected the pattern on the response template. This study produced negative findings; the center marker did not have any apparent effect on error distributions.

Exps. IV and V were designed to test whether or not the failure of foveal facilitation in Exps. I and III was due to a masking of the center elements by the fixation marker. Both Exps. IV and V used a smaller fixation marker than was used previously, using 28- and 12-element patterns, respectively. Results of both Exps. showed that foveal facilitation did occur with the small fixation marker, suggesting that visual masking by the large fixation cross had prevented the foveal facilitation in Exps. I and III.

Findings of the present research provide further evidence that mnemonic as well as sensitivity factors are responsible for differential accuracy in tachistoscopic pattern perception. The phenomena of end-segregation, primacy, and foveal facilitation were demonstrated for patterns of different lengths.

THE END-SEGREGATION EFFECT IN TACHISTOSCOPIC

PERCEPTION OF BINARY PATTERNS

INTRODUCTION

The present research investigates some of the more influential component processes involved in tachistoscopic pattern perception. These include: motor factors, left-field superiority, mnemonic factors and certain predisposition or set factors. The primary interest is an analysis of the end-segregation effect--the tendency for *S* to reproduce more accurately those elements which appear in the more extreme positions.

The present series of experiments, following Camp and Harcum (1964) and Harcum (1969), employ binary patterns consisting of rows of circles, some of which are filled so as to make them black dots, and some of which are unfilled, leaving a black ring on a white background. The following is an example of a twelve-element binary pattern:

● ● ○ ● ○ ○ ● ○ ○ ● ○ ●

Each single filled or unfilled circle is a binary element. When such a pattern is tachistoscopically exposed, the *S*'s task is to perceive the pattern of filled or unfilled circles and to reproduce them on a response sheet.

Historical Analysis

When such binary elements of blackened and outlined circles are presented to a subject, it might be expected that the errors for elements at various retinal positions would conform to conventional gradients of visual sensitivity. As Harcum (1966) notes, such retinal sensitivity gradients would show fewest errors for stimuli nearest ocular fixation and monotonically increasing functions of errors for elements at greater eccentricities. However, the distribution of errors among elements usually does not conform to the expectation of this conventional gradient, but rather it more closely approximates the bowed serial-position curve of errors in verbal learning (Harcum, 1966). Clearly, such errors are more frequent for the binary elements which appear within the spatial array of stimuli, even though these elements are closer to ocular fixation. Also, Harcum notes fewer errors in the reproduction of elements nearer the ends of the array.

Motor Factors

Although the phenomenon of left-field superiority has been well substantiated (Mishkin and Forgays, 1952), there is also some evidence for a tendency to more accurately perceive elements to the right of fixation (Dyer and Harcum, 1961). Heron (1957) notes that with simultaneous presentation (stimuli on both right and left of fixation) of letter-groups, significant differences are found showing better recognition to the left of fixation. However, with successive presentation of letter groups (either left or right of fixation) significant differences are found showing better recognition to the right of fixation.

In an attempt to explain this apparent conflict in findings, Heron postulates a "post-exposural process"--a process of neural events occurring after retinal stimulation--and suggests that this is a motor component of the perceptual process. Heron believes that tendencies toward eye movements (or implicit eye movements) persist in time after the stimulus presentation has terminated. Camp (1961) notes that these hypothetical tendencies parallel the two basic eye movements used in reading English. The first of these eye movements is the movement from right to left made while shifting fixation toward the beginning of a line of print. The second is the saccadic left-to-right movement made while reading a line of print. Thus, differences in field superiority are contingent upon the amount of conflict which exists between these two tendencies, as well as other component factors (e. g., type of stimuli presented and manner of presentation).

In the perception of an equal number of binary elements on each side of fixation, this conflict in tendencies generally results in the left tendency dominating first. Such is the case not because this left-ward movement is an inherently dominant tendency, but rather because of certain habitual methods of perceiving organized material (Camp, 1961). Dyer and Harcum (1960) suggest that such a tendency to start at the beginning, which is assumed to be the left end, is established in part by the reading habit and also by certain physiological qualities such as cerebral hemisphere dominance or eye-dominance factors.

Left-Field Superiority

Data suggesting that objects presented to the left of fixation are generally more clearly perceived than objects presented to the right date back to research conducted by Dallenbach (1923). He reported appreciable differences in the relative vividness of test-patches presented to the left of fixation for right-handed subjects. Dallenbach attributed such differences to the handedness or dominant cerebral hemisphere of the subject, such that stimuli presented to the non-dominant hemisphere were found to be more attense (clear to the senses). There is a relatively comprehensive body of research which reports the phenomenon of left-field superiority (e. g., Anderson, 1946; Anderson and Crosland, 1933).

Hebb (1949), Heron (1957), and Harcum (1957a, 1957b) have taken similar theoretical positions in attempting to explain this left-superior phenomenon. Harcum and Dyer (1962) note that the recognition of visual stimuli depends upon the functional superiority of their perceptual organization. They postulate that when visual stimuli are too numerous or complex to be perceived in their entirety, they are perceived via some sequence or scanning mechanism which begins at some reference point and proceeds even though the eyes are fixed. This mechanism is thought to proceed, "in the manner of eye-fixations if eye movements could be made (Harcum and Dyer, 1962, p. 57)." It is further postulated that those elements covered first by this mechanism will produce fewer recognition errors in report. Harcum and Dyer (1962) also note that such a <u>primacy effect</u> is a "general behavioral attribute and not specifically a mechanism of visual perception (p. 57)." Indeed, Ebbinghaus (1902) noted a primacy effect in the rote memorization of nonsense syllables.

Such an effect has been likened to a scanning of the eyes across a visual stimulus in reading (Bryden, 1960; Heron, 1957; Terrace, 1959). The fact that the primacy effect is in some way analogous to the process of reading is further substantiated by Crosland (1931, 1939), who has repeatedly found superior performance for letter positions to the left of fixation. He has also noted (1939) that the effect is greater for superior than for inferior readers.

Mnemonic Factors

The function that mnemonic organizing processes have in the primacy effect has been investigated by Harcum (1964) and Harcum and Skrzypek (1965). These authors have shown that the discriminability of binary element patterns is determined by some organizational process of memory rather than by visual sensitivity as such. When enumerating several common processes which seem to have a direct relationship to the memory's function in the primacy effect, Harcum (1967a) included, under the rubric of information-translation, "element discrimination, selective analysis of persisting traces, and the organization of information for storage in memory (p. 51)."

To be sure, the question concerning what happens during the intervening stage when information is being transformed from input to output is clearly relevant to our understanding of this primacy effect. Some theoretical suggestions have been offered by Bryden (1967), Harcum (1967a), Heron (1957), and Lashley (1951) as to how this serial organization of information may be conceptualized.

White (1970b), in an attempt to analyze determinants of element span errors, has outlined the processes involved when stimuli are briefly presented about a reference point. When binary element patterns are exposed, there are retinal traces established with varying degrees of strength. An S can only correctly report on a limited number of binary elements. This number defines the "span of immediate memory (Sperling, 1960)." Sperling notes that observers commonly assert they can see more than they can report. Thus, he suggests that the memory sets a limit on a process that is otherwise rich in available information.

A reasonable assumption is that the nearer the binary element positions are to a fixation point, the stronger the retinal traces will be. However, there is also a good deal of evidence (Harcum, 1966; White, 1970b) that stimulus elements at the ends of a line pattern will establish better retinal traces than stimuli adjacent to end positions and to fixational or foveal positions, that is, those nearer the point of fixation. The reason for this may be that binary elements in intermediate positions are spatially masked in the visual input stage by "end-segregated" and "foveally-centered stimuli (White, 1970b)." Although the locus of this masking effect is not yet certain, Sperling (1963, 1967) and Weisstein (1966) favor the central storage stage.

Sequential Scanning. When information of the binary pattern is established in the memory traces, it is immediately transmitted to a short-term visual storage where a sequential scanning mechanism operates on it. Such a mechanism operates according to certain habits acquired during reading. Harcum (1966) refers to the net effect of these habits as the "r" factor which includes certain "components of inter-element interference or location-confusability of elements, as well as primacy and recency mechanisms in selective attention (p. 681)."

White (1970b) suggests that sequential or serial analysis of the brief memory traces is indicated by the fact that overt reporting is a serial and not a parallel process. Glanzer (1966) reports that an increase in verbalization length results in a more tilted or skewed serial position curve and that a similar effect is produced by the reduction of exposure time. These effects require some amount of time, indicating that encoding of the input occurs sequentially. Harcum (1967a) notes the similarity of the distribution of errors in the reproduction of elements within tachistoscopic patterns to the serial position curve of errors in rote learning and also implies that "each observation in perception is a miniature task in serial learning (p. 51)." Thus, the similar processes involved in the perception of binary patterns and those involved in serial learning are apparent.

During the sequential scanning process of the stored information, the memory traces are rapidly fading, and by the time the scan reaches some of the traces they will have faded below threshold before being reported. Thus, stimuli appearing at the ends of a line and in foveally proximate positions will establish stronger memory traces than stimuli shown in intermediate positions (White, 1970b). Indeed, Hershenson (1969) reports results which corroborate these predictions. There is a good deal of evidence supporting the fact that stimulus elements reported first produce least errors and those reported late, most errors (Ayres, 1966; White, 1970a).

Sperling (1960) has shown that at the time of stimulus exposure, and for a few tenths of a second thereafter, observers have two or three times as much information available as they can later report. Such information fades very rapidly, and within one second after the presentation the memory traces no longer exceed the memory span.

End-Segregation Factor. Woodworth (1938) suggests that the increase in errors for centrally located elements may be due to a spatial "masking," in which the outlines of all elements mutually inhibit one another, and binary elements nearer to the end of the pattern are progressively less inhibited. Woodworth and Schlosberg (1958) note that this effect may be attributed to a loss in element contrast with the background for the embedded elements. On the other hand, Woodworth and Schlosberg (1954) do believe that there is some kind of a contrast effect operating which accounts for the fact that the ends of a homogeneous target are ordinarily the most identifiable. Harcum (1957a) referred to the superior performance for the end elements in pattern perception as an "end-segregation effect"--suggesting that "the elements were more salient perceptually because of their unique relative spatial positions (Harcum, 1966, p. 689)." Because these end-segregated elements have the most differentiated positions, they have a clear advantage for storage in the memory system over binary elements embedded within the conglomeration. Thus, it is these end-segregated elements which benefit most by the above-mentioned primacy effect, which insures that their swiftly fading memory traces will exceed the threshold for recollection, whereas more embedded elements will probably not exceed this threshold.

In some early studies, Harcum and Rabe (1958) suggested that as the length of the binary pattern is increased, there should be a greater primacy effect favoring the left because of the greater need for selective attention. They argued that if the target is too long for the observer to differentiate the elements at the extreme left, the tendency for left-to-right scanning should be reduced. Clearly, with very short patterns, a selective perceptual process should not be necessary (Harcum, 1964). Tinker (1929) reports evidence that "responses are more uniformly correct with shorter series (p. 227)." Thus, Harcum (1964) reasoned that, within limits, target length should be a variable affecting left-right differences in perceptual accuracy.

In attempting to test the hypothesis that perceptual accuracy for tachistoscopic patterns is determined by processes of mnemonic organization, rather than by retinal sensitivity for the individual elements, Harcum (1964) varied the pattern lengths and/or numbers of binary elements appearing at each exposure. Binary patterns having both more (*i. e.*, 17) and fewer (*i. e.*, 5) elements than previous studies (Harcum, 1958a, 1958b, 1958c) were used in this study. Harcum's prediction was that with the 17-element targets the observer would be unable to differentiate elements on the extreme left and thus be unable to attend selectively to them. These targets were "to provide a kind of control condition in which the data have the best chance to approximate a conventional sensitivity function, because of reduced effects of the left-to-right scanning process (Harcum, 1964, p. 352)." Harcum did not expect gradients of errors with the 5-element targets because selective attention should have been unnecessary.

Although Harcum's (1964) results supported his initial hypothesis (that perceptual accuracy for tachistoscopic patterns is determined by processes of mnemonic organization, rather than by visual sensitivity), the 17-element targets did not exhibit the predicted minima of errors near fixation, with equality of errors to the left and right. Since fewer errors were exhibited for the first several elements on the left, Harcum concluded that the subjects apparently were able to differentiate and attend selectively to those elements.

In light of Harcum's (1964) failure to eliminate the end-to-end scanning with a 17-element stimulus pattern, another experiment (Harcum, 1969) was designed, utilizing 28 element positions. The intent of this experiment was "to prevent the usual consistent directional scanning of patterns, consequently eliminating laterality effects in the perception (Harcum, 1969, p. 504)." As predicted, Harcum's (1969) results demonstrated symmetrical error distributions for each viewing condition, with a minima of errors near fixation. These data were grossly different from the usual shape of the error distribution, and they supported Harcum's hypothesis.

Predisposition Factors

There is a good amount of evidence which suggests that a "pre-exposure set" may influence perceptual accuracy (e. g. Camp and Harcum, 1964; Haber, 1966; White, 1969).

Camp and Harcum (1964) found that when the specific orientation relative to fixation was unknown to an observer before stimulus exposure, the usual tendency for greater accuracy for elements at the left could be overcome. This was accomplished when more than half of the elements had appeared to the left of the fixation point. Camp and Harcum suggest that their results further support the conclusion that the motor habits discussed by Heron (1957) do have some kind of primacy over other mechanisms in this kind of task. If such mechanisms prove to be efficient for a given situation, they retain their dominance. Camp and Harcum conclude that the form of the response recording affected the results. Clearly, a subject brings a response-set to the experiment, which predisposes him to respond perceptually in a fixed manner. If such a predisposition is not appropriate for the particular situation, a previously subordinate perceptual response emerges to dominate the behavior (Camp and Harcum, 1964).

In an experiment in which they manipulated pre- vs. post-knowledge of required reproduction sequences for binary patterns, Harcum, Hartman, and Smith (1963) concluded that the effects of responding sequence alone cannot account for the hemifield differences, but rather a perceptual factor apparently corresponds to a sequential analysis of the memory traces of the exposure. They suggest that "this perceptual process can be influenced by the set of the observer to mark his responses in a particular sequence (p. 271)."

Harcum (1965), in an experiment which tested the hypothesis that prior knowledge of isolation is critical for an isolation effect in perception, found that only those subjects who knew, before exposure, that a specific element would be isolated demonstrated an "isolation-effect" in terms of fewer errors. Harcum suggested that the effect was attributable to a selective distribution of attention among stimulus elements. More recently, Harcum (1968) has argued that different error distributions are generally caused by different perceptual strategies, which are usually established by subjects prior to stimulus exposure.

EXPERIMENT I

Purpose of the Study

The present experiment has two purposes. The first is to systematically investigate the "end-segregation effect," in which end elements are perceived more accurately due to their relatively unique positions. An attempt will be made to establish upper and lower thresholds for this mechanism. It is evident (Harcum, 1969) that the mechanism is not operative when an observer is presented with a 28-element stimulus exposure and that it is barely operative with 17-element exposures (Harcum, 1964). The primary questions that the present study will address itself to are, "at what point does the end-segregation effect become functional?" and "at what point does it no longer seem to be useful?"

In light of the evidence cited above, it was expected that pattern lengths of 12, 16, and perhaps 20 elements would be most susceptible to an end-segregation effect. That is, it was expected that these pattern lengths would have fewer errors for the extreme positions. However, it was not expected that a 4-element pattern would be as susceptible to such a mechanism due to the simplicity of the pattern. On the other hand, it was predicted that the 28-element pattern, due to its complexity, would produce no end-segregation, thus replicating Harcum's (1969) findings.

Although it was expected that there would be an overall increase in correct responding about fixation, this foveal facilitation was expected to be more emphasized in the longer pattern lengths (_i. e._, 20 and 28 elements). Such a prediction was made in belief that these lengths would be so complex that the Ss would probably respond primarily only on foveally located stimuli.

The second purpose of this experiment is to investigate the effects a predisposition or set may have on the end-segregation phenomenon. In order to study the effects of S's predisposition to respond to a given pattern length, binary patterns were presented according to a modified method of limits (sequential presentation) as well as a method of constant stimuli (random presentation). Thus, it was expected that those Ss presented with exposures via a modified method of limits would have fewer errors due to the fact that they should be approaching the experiment with some predisposition. That is, they would know how many elements to expect on succeeding trials; whereas Ss in the random presentation condition would not have such information with which to approach their task. Such results are predicted on the basis of previous evidence presented for the effect of pre-exposural set on perceptual accuracy (e. g., Camp and Harcum, 1964; White, 1969). Predicted results would corroborate Harcum and Friedman's (1963) findings that orderly sequential presentation of binary elements produces superior performance for individual Ss when the sequence proceeded from the end demonstrating more errors in the control, random presentation condition.

Another prediction was that there would be fewer errors in the direction toward which Ss' eyes initially moved after the exposure. It was expected that such movement would generally be to the left of fixation. Bryden (1960, 1961) and Crovitz and Daves (1962) report data which supported such predictions and which are clearly consistent with the theoretical position outlined above. Considering evidence presented by Ayres (1966) and White (1970a), it was also expected that fewer errors would occur among those elements which were reported first in the response sequence.

A unique contribution of the present study is that it employs pattern length as a major variable which will be systematically presented to each of the Ss. Thus, the above-mentioned mechanisms will be investigated as factors determining different response distributions.

Method

Subjects

The Ss were three, right-handed, experimentally naive women undergraduate students of The College of William and Mary. Each S was paid for her services and each had 20-20 vision or better. Handedness and visual capacity were determined by self-report.

Apparatus

A modified Harvard-type tachistoscope was used in this experiment (Camp, 1961). Two four-watt fluorescent tubes illuminated the pre-exposure field at approximately 2 ft-L. A small "x," consisting of two .5 mm. lines located in the center of this field, served as the fixation point. Four four-watt fluorescent tubes illuminated the exposure field at approximately 1.5 ft-L. The binary patterns were horizontally located in this field; the center of the pattern was at the same vertical height as the fixation point. Exposure time was controlled by a Lafayette 12-MC electronic interval timer, which was set to yield an exposure duration of approximately 150 msec. for the stimuli.

The binary patterns were constructed by typewriting a horizontal row of zeros on white stimulus cards and filling in various zeros with black India ink. Each element was 13.2 in. through the horizontal diameter, with spaces between elements subtending 17.6 in. Total lengths of patterns subtended from 1.9° for the 4-element pattern to 13.4° for the 28-element pattern. There were either 4, 12, 16, 20, or 28 blackened or open binary elements arranged to produce different stimulus patterns. Half of the given number of elements which appeared on any one exposure appeared on each side of fixation, with each element position blackened equally often and with half of the elements blackened on each side of fixation in each exposure. The binary patterns used are reproduced in Appendix A.

<u>Procedure</u>

The general procedures followed were similar to those of previous studies concerning tachistoscopic perception of binary patterns (*e. g.*, Camp and Harcum, 1964). However, there were deviations from this general procedure so that certain factors such as pattern length and predisposition or set phenomena could be studied within the experimental design.

The experiment was conducted using each *S* as her own control. Treatments were according to the following order so as to minimize practice effects:

$\underline{S}_1$	Random	Ascending	Descending
$\underline{S}_2$	Ascending	Descending	Random
$\underline{S}_3$	Descending	Random	Ascending

When *Ss* were undergoing the ascending condition (sequential exposures), they began with patterns of 4 element positions and gradually worked up to patterns containing 28 element positions. Increases in number of element positions were made on successive experimental sessions. The descending sequential exposures were mirror images of the ascending presentation. The random condition included exposures ranging from 4 to 28 element positions. Order of presentation was designated according to a random numbers table with the restriction that no more than two patterns of the same length appeared succeedingly and each length appeared an equal number of times.

Each S was completely briefed on the nature of the experimental design, viz., the order in which the different conditions would be presented to her. Before each session, Ss were asked to read an instruction sheet describing the experimental task (see Appendix B). Experimental sessions consisted of ten practice or warm-up trials and forty test exposures. The second half of the exposures consisted of the first twenty targets turned upside-down and their respective mirror images presented. Each S normally completed only one session on a given day, and a session lasted approximately forty minutes.

Eye movements were recorded by a portable E & M Instrument Company Physiograph Model Four. Silver disc electrodes were attached (pasted with Grass Electrode Paste and then taped) to the immediate left side of S's left eye and also to the right side of her left eye on the bridge of her nose. An additional ground electrode was attached to her left ear lobe.

The S's fixational accuracy was maintained by instruction. She was informed that her eye movements were being recorded and that a stimulus would be presented only after E said "ready" and the polygraph output indicated that she was in fact fixating on the fixational cross. Ss were instructed to continue fixating until the stimulus was presented and then promptly to mark on the response sheet their reproduction of the pattern that was presented. The response templates contained a horizontal row of the presented number of typewritten zeros.

In order to minimize the possibility of any pre-exposural set on the part of Ss in the random condition, response templates were provided while the Ss were fixating on the fixation marker. A similar procedure was followed in sequential conditions so as to maintain timing controls. The order of S's sequence of responses was recorded by E, who furnished the stimulus templates from the back of the tachistoscope. Such recordings were concealed from S.

An error was scored each time S marked an open element in the stimulus pattern as filled or left a blackened element unfilled. Errors were tallied as a function of pattern length and serial position of the elements for each S under each experimental condition.

Results

The results showed an end-segregation effect for pattern lengths of 4, 12, and 16 elements and no end-segregation for pattern lengths of 20 and 28 elements. Laterality differences were also significant showing a significantly larger number of correct responses to the left of fixation as compared to the right. There were no significant differences between different orders of presentation. A high agreement was found between Ss' initial overt responses, correct responses, and eye movements.

The mean proportion of correct responses at each element position for each of the five pattern lengths is presented in Figures 1 - 4. It is apparent in Figure 1 that there is a clear end-segregation effect for the 4-element pattern. The curve representing correct responses to the 12-element pattern also shows end-segregation. However, here it is only the left end that is responded to more accurately. Figure 2 shows the

FIGURE 1

MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION

FOR THE 4- AND 12-ELEMENT PATTERNS

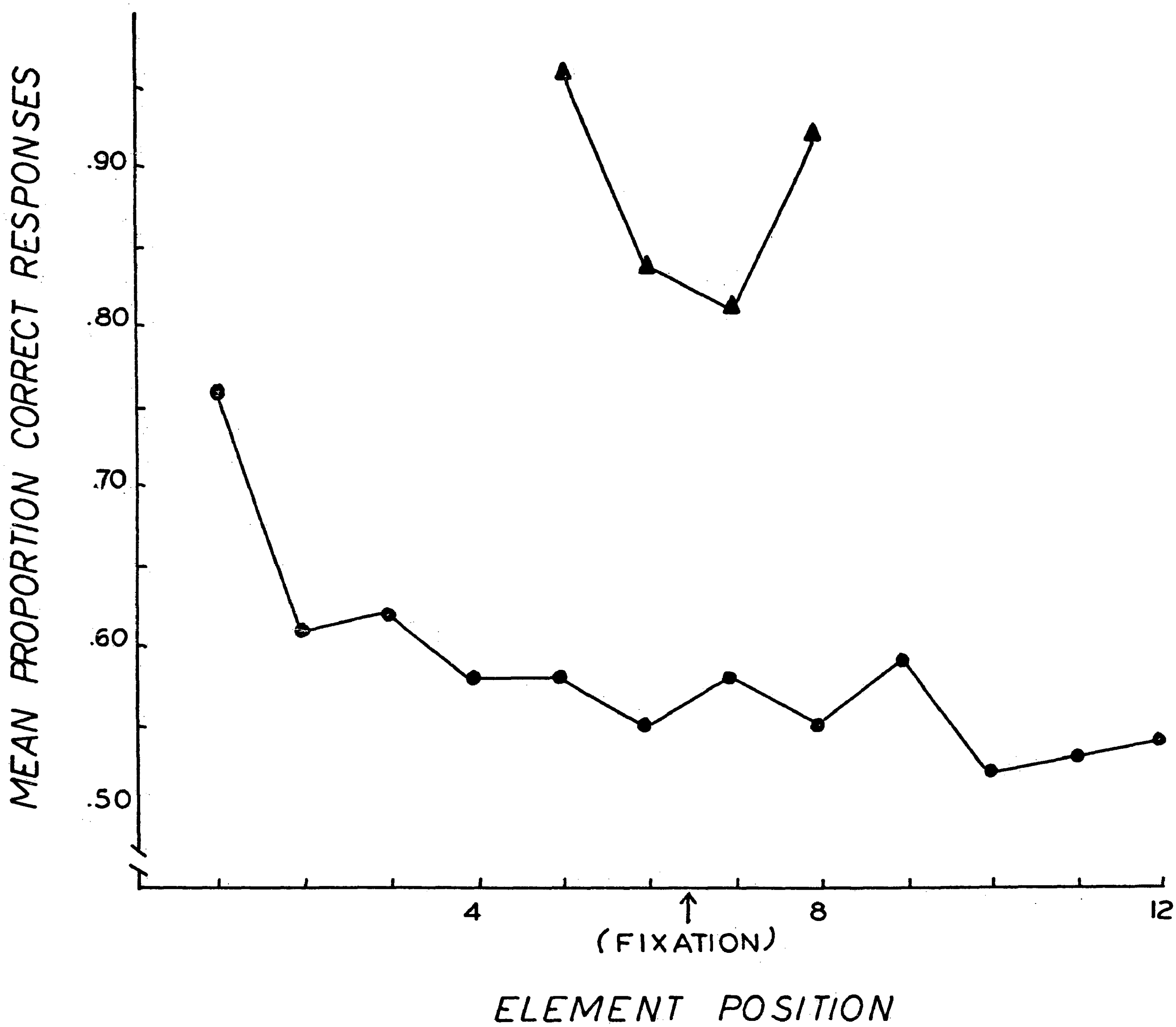

MEAN PROPORTION CORRECT RESPONSES
.90
.80
.70
.60
.50
4
8
12
(FIXATION)
ELEMENT POSITION

FIGURE 2

MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION FOR 16-ELEMENT PATTERNS

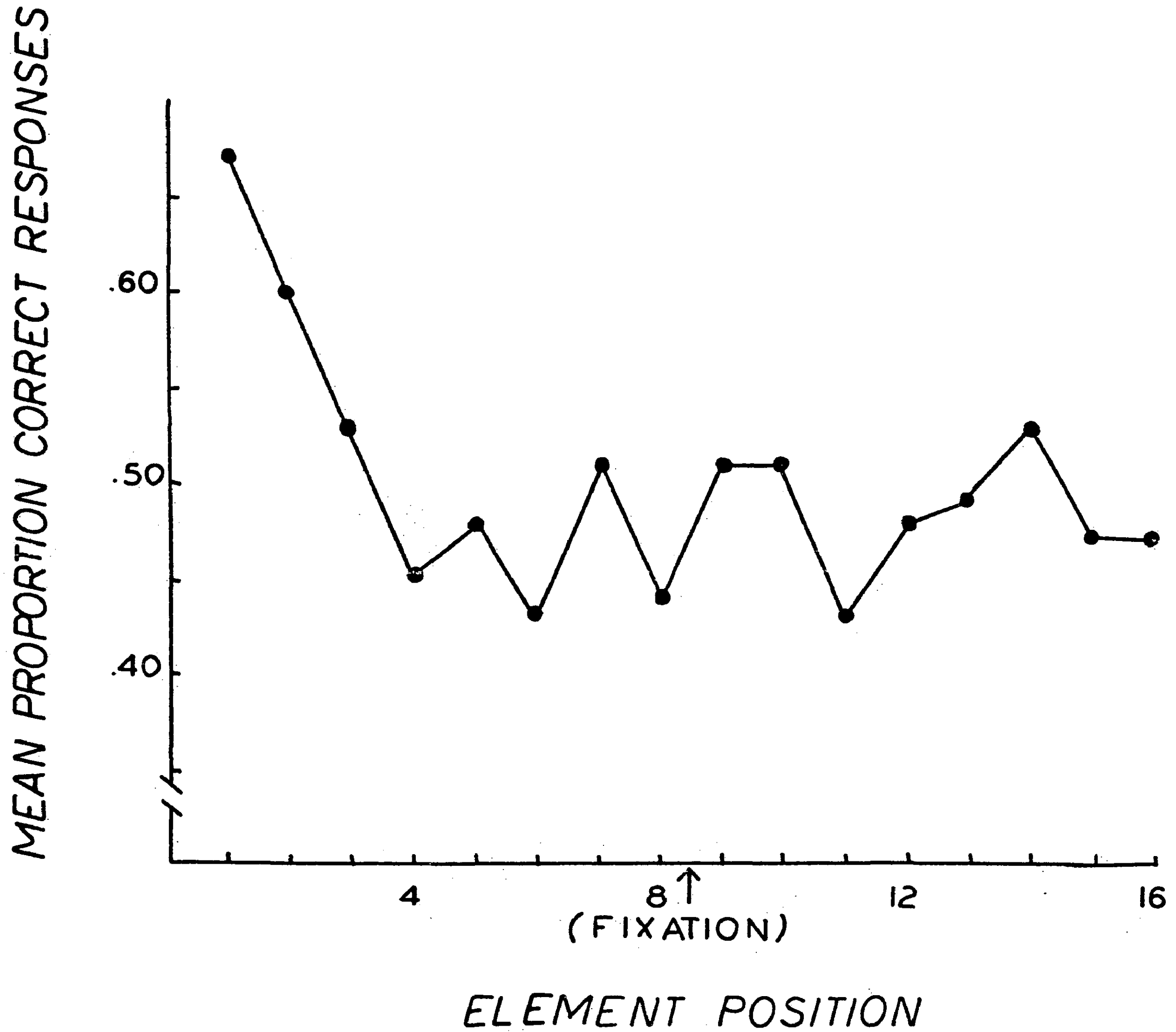

MEAN PROPORTION CORRECT RESPONSES
.60
.50
.40
4
8
12
16
(FIXATION)
ELEMENT POSITION

FIGURE 3

MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION

FOR 20-ELEMENT PATTERNS

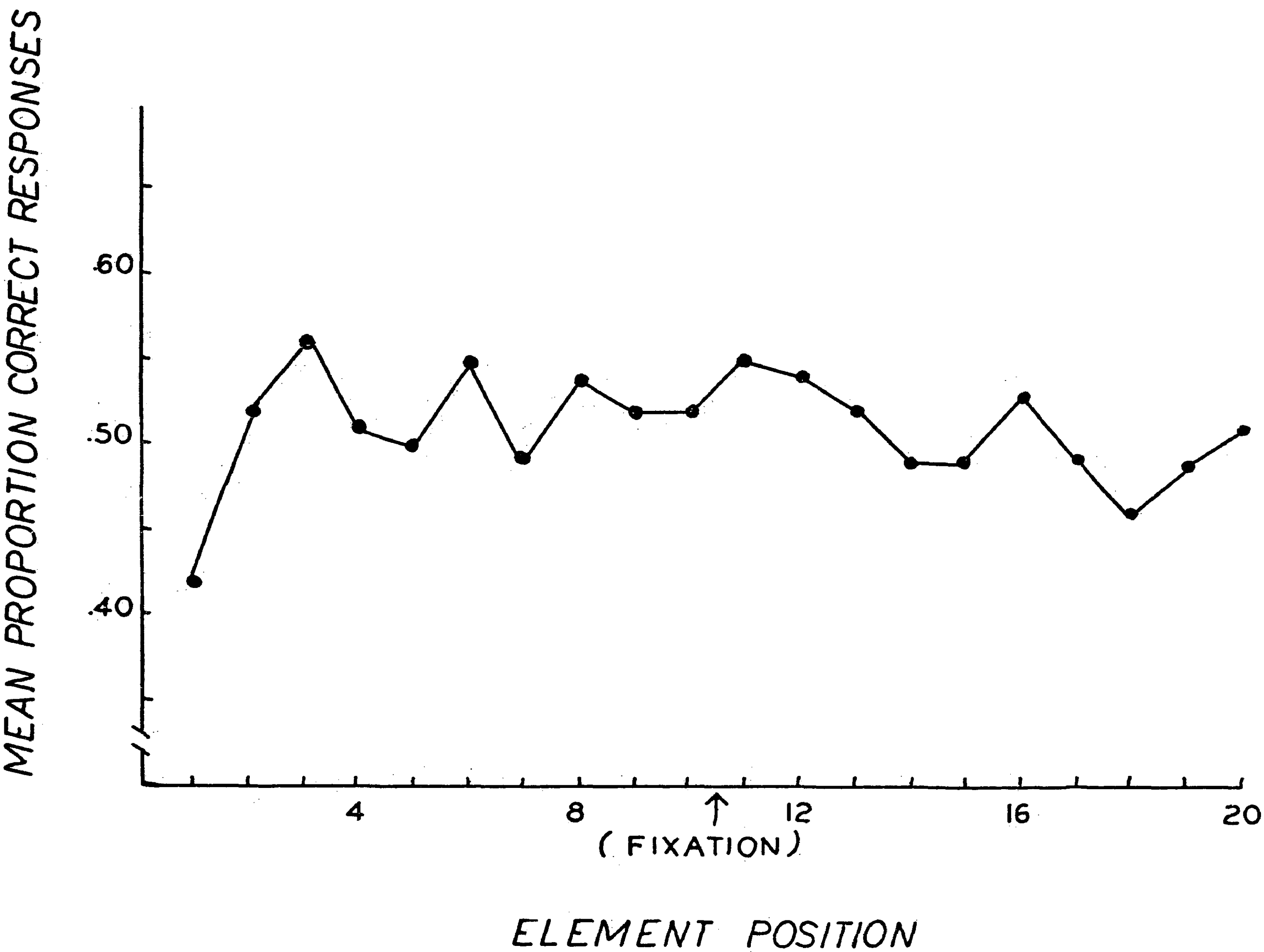
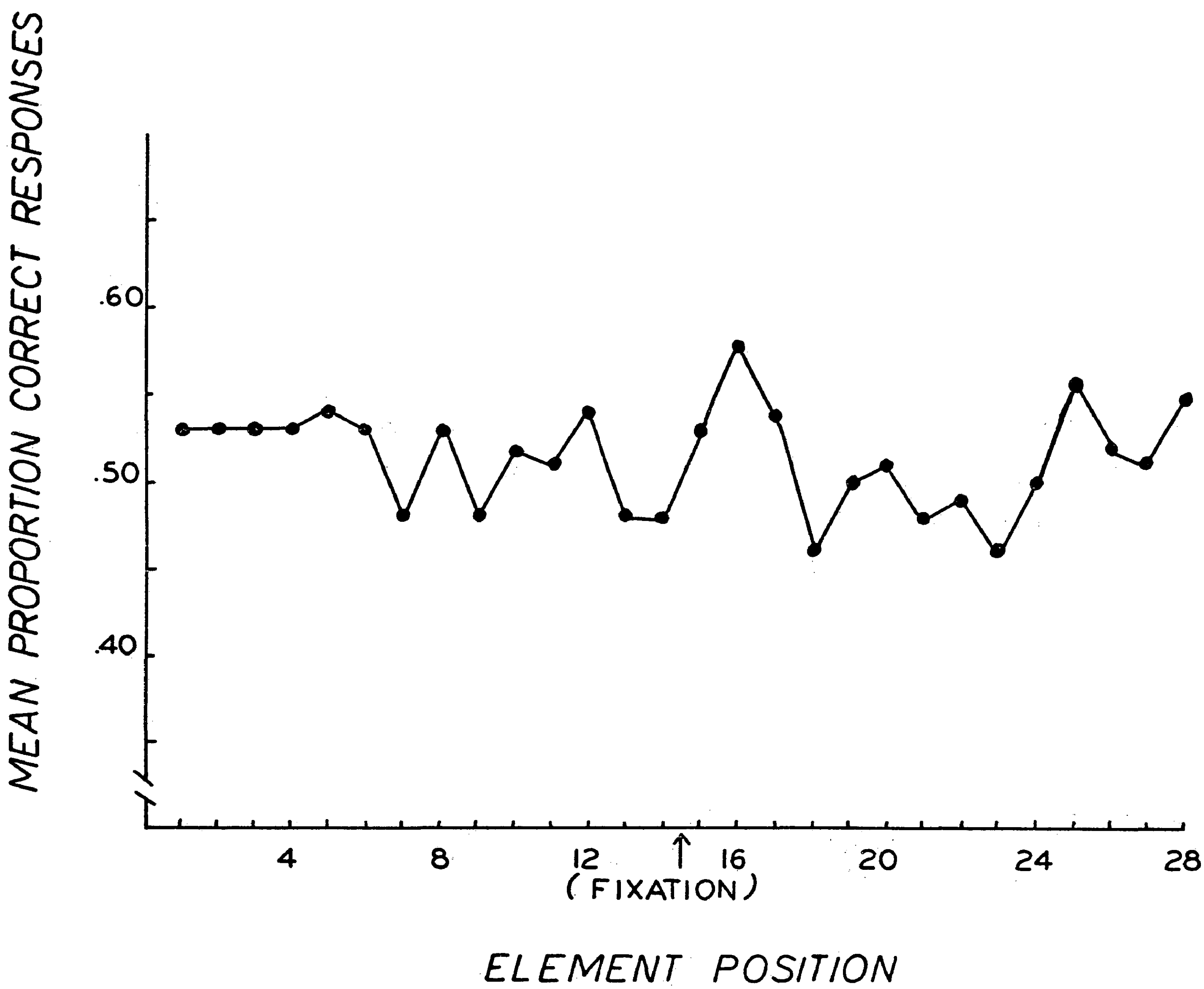

MEAN PROPORTION CORRECT RESPONSES
.60
.50
.40
4
8
12
16
20
(FIXATION)
ELEMENT POSITION

FIGURE 4

MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION

FOR 28-ELEMENT PATTERNS



MEAN PROPORTION CORRECT RESPONSES
.60
.50
.40
4
8
12
16
20
24
28
(FIXATION)
ELEMENT POSITION

response curve for the 16-element pattern. It is clearly similar to that of the 12-element pattern; however, the left end is not responded to quite as accurately. Figures 3 and 4 present proportion correct response curves for 20- and 28-element pattern lengths respectively. There is no apparent end-segregation shown in these curves.

A four factor, factorial analysis of variance with repeated measures on the last two factors was done on the mean proportion correct responses at different element positions. The four factors tested were: pattern length (A), order of presentation (B), laterality (C), and end-segregation (D). Mean scores for the 4- and 28-element patterns were omitted from this first overall analysis, because it seemed that some type of masking phenomenon might have biased the results of the analysis in favor of end-segregation. (This problem is studied further in Experiments III, IV, and V.)

Table 1 presents the summary table for this analysis of variance. As can be seen from this table, the length of the pattern was significant ($F_{2,\ 18} = 28.09$, $p < .001$), and the magnitude of the effect (Friedman, 1968) was large with $r_m > .9$. Multiple t-tests were performed to compare response differences to the various pattern lengths. It was found that there were significantly more correct responses to the 12-element pattern as compared to both the 16-element pattern ($t_{18} = 6.83$, $p < .001$) and the 20-element pattern ($t_{18} = 6.09$, $p < .001$). However, the difference between patterns of 16 and 20 elements was not significant.

The order of presentation was clearly not significant, as shown in Table 1.

Laterality differences were also significant ($F_{1,\ 18} = 11.84$, $p <$

TABLE I

ANALYSIS OF VARIANCE SUMMARY TABLE

Source	df	MS	F
Between Groups	26		
Pattern length (A)	2	153.66	28.09 $p < .001$
Order of Presentation (B)	2	2.00	.36
A X B	4	4.31	.79
Subjects Between Groups	18	5.47	
Within Groups	135		
Laterality (C)	1	81.88	11.84 $p < .005$
A X C	2	23.88	3.45
B X C	2	5.81	.84
A X B X C	4	2.13	.31
C X Subjects Within Groups	18	6.91	
End-Segregation (D)	2	110.69	20.55 $p < .001$
A X D	4	13.34	2.47
B X D	4	2.16	.40
A X B X D	8	5.20	.96
D X Subjects Within Groups	36	5.39	
C X D	2	20.22	4.17 $p < .025$
A X C X D	4	19.53	4.03 $p < .05$
B X C X D	4	3.23	.67
A X B X C X D	8	7.11	1.47
C X D X Subjects Within Groups	36	4.85	
Total	161		

.005, $r_m = .6$). There was a significantly larger number of correct responses to the left of fixation as compared to the right.

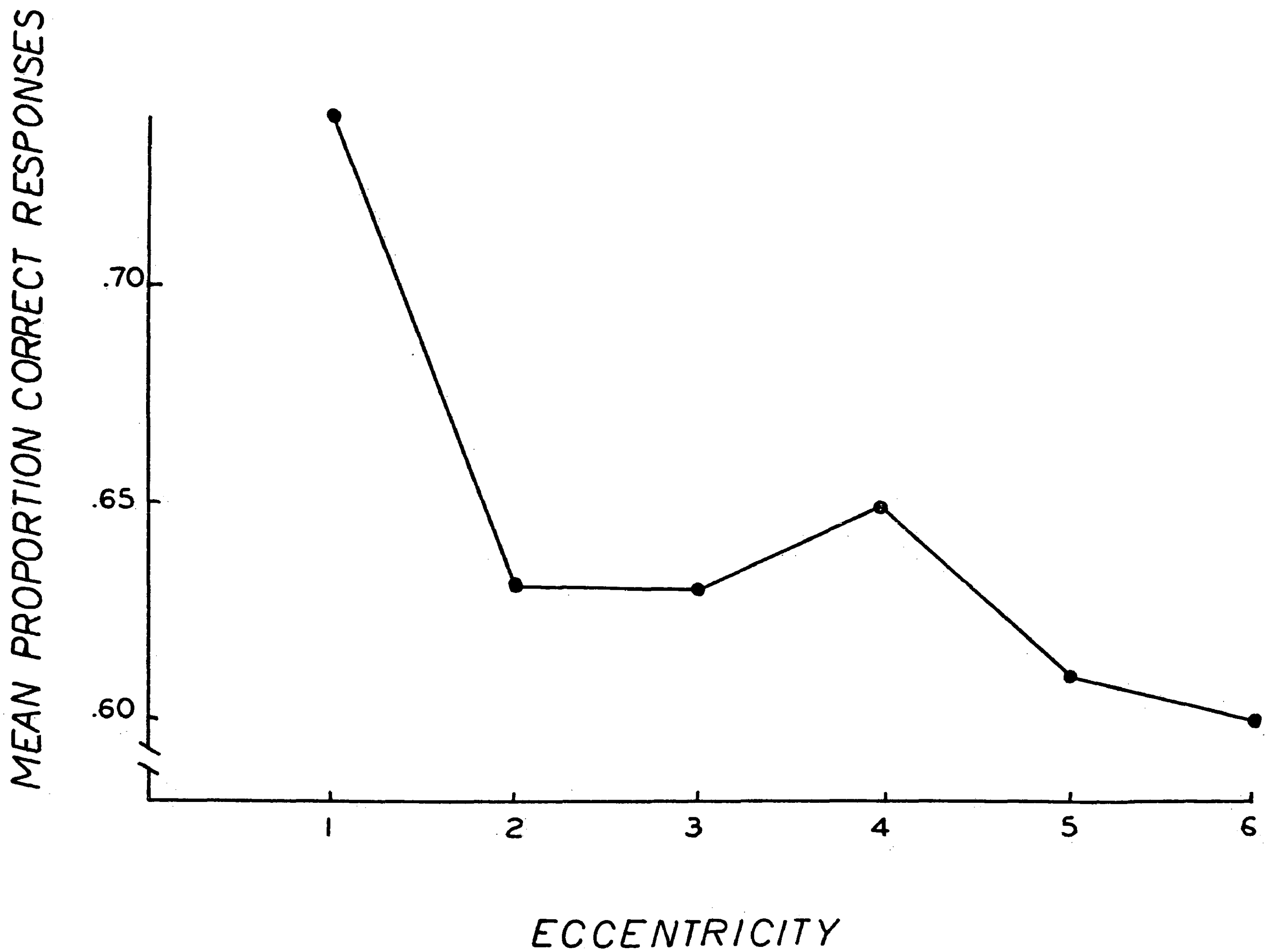
The end-segregation factor was tested by averaging correct responses into three groups of mean scores. The first mean consisted of correct responses for the two left-end element positions; the second mean consisted of scores for element positions between the two left-end positions and the two right-end positions, and the third mean consisted of scores for the two right-end element positions.

As is apparent in Table 1, the end-segregation factor is significant ($F_{2, 36} = 20.55$, $p < .001$, $r_m > .7$). Multiple t-tests were performed comparing the ends of the patterns with the middle and the mean correct response for the two left-end elements significantly differed from that of the middle elements ($t_{36} = 23.07$, $p < .001$) and from that of the two right-end elements ($t_{36} = 29.83$, $p < .001$). The middle elements also significantly differed from the two right-end elements ($t_{36} = 6.76$, $p < .001$).

As shown in Table 1, the laterality by end-segregation (C x D) interaction is significant ($F_{2, 36} = 4.17$, $p < .025$, $r_m = .45$). Figure 5 presents mean proportion correct responses for different eccentricities. Eccentricity consists of six scores of mean correct responses. The first mean score consists of correct responses to the two left-end elements; the second consists of correct responses to elements between the two left-end elements and the two elements to the immediate left of fixation; and the third mean score consists of correct responses to the two elements to the immediate left of fixation. Mean scores to the right of fixation were derived in a like manner. It is clear from this curve that the left-most elements were responded to more accurately overall.

FIGURE 5

MEAN PROPORTION CORRECT RESPONSES AT DIFFERENT ECCENTRICITIES FOR ALL PATTERN LENGTHS


MEAN PROPORTION CORRECT RESPONSES
.70
.65
.60
1
2
3
4
5
6
ECCENTRICITY

Multiple t-tests were performed comparing differences between mean correct responses. The t-values for all possible comparisons are presented in Table 2. As is shown in this table, all comparisons are at least significant at the .05 level except those for the responses to the middle and right elements to the left of fixation; and those to the immediate left of fixation as compared to those to the middle-right of fixation. It is apparent that all comparisons made with the mean proportion correct score for the left-end element positions are significant ($p < .001$). Comparisons made with the mean score for the right-end element positions are also significant ($p < .05$).

It is also apparent in Table 1 that there is a small but significant interaction ($F_{4, 36} = 4.03$, $p < .05$, $r_m = .55$) between pattern length (A), laterality (C), and end-segregation (D). Dunn's Multiple Comparison Procedure was used to compare the differences among means involved in this interaction. These differences are presented in Table 3. Largest mean differences were found between 12-element patterns as compared to 16- and 20-element patterns. Differences were largest for a given pattern when the extreme left positions were compared to other positions on either side of fixation.

A measure of agreement between Ss' initial overt responses, correct responses and eye movements was calculated employing a Chi-square Test. As shown in Table 4, this agreement was found to be significant ($p < .001$). The magnitude of the agreement was also quite large.

A second four factor, factorial analysis of variance was done on the mean proportion correct responses. This analysis differed from the first one in that data for the 28-element pattern was included. The results of this analysis showed the pattern length factor not to be

TABLE 2

t VALUES COMPARING DIFFERENCES BETWEEN LEVELS OF LATERALITY (C_1- left, C_2- right) AND END-SEGREGATION (D_1- left, D_2- middle, D_3- right)

	C_1D_1	C_1D_2	C_1D_3	C_2D_1	C_2D_2	C_2D_3
C_1D_1	----	16.99***	18.26***	14.18***	20.17***	22.24***
C_1D_2		----	1.27	2.80**	3.19**	5.26***
C_1D_3			----	4.07***	1.92	3.99***
C_2D_1				----	5.99***	8.06***
C_2D_2					----	2.07*
C_2D_3						----

*$p < .05$
**$p < .01$
***$p < .001$

TABLE 3

DIFFERENCES AMONG MEANS FOR PATTERN LENGTH X LATERALITY X END-SEGREGATION (A X C X D) INTERACTION

INTERACTIONS		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	MEANS	57.33	57.83	59.72	60.00	61.17	61.67	61.78	62.17	64.00	65.83	66.50	67.83	68.50	71.67	76.17	82.00
1 $A_2C_1D_2$	56.33	1.00	1.50	3.39	3.67	4.84	5.34	5.45	5.84	7.67	9.50	10.17	11.50	12.17	15.34	19.84	25.67
2 $A_2C_2D_3$	56.33	1.00	1.50	3.39	3.67	4.84	5.34	5.45	5.84	7.67	9.50	10.17	11.50	12.17	15.34	19.84	25.67
3 $A_2C_1D_3$	57.33	---	0.50	2.39	2.67	3.84	4.34	4.45	4.84	6.67	8.50	9.17	10.50	11.17	14.34	18.84	24.67
4 $A_2C_2D_2$	57.83		---	1.89	2.17	3.34	3.84	3.95	4.34	6.17	8.00	8.67	10.00	10.67	13.84	18.34	24.17
5 $A_3C_2D_2$	59.72			---	0.28	1.45	1.95	2.07	2.45	4.28	6.11	6.78	8.11	8.78	11.95	16.45	22.28
6 $A_3C_2D_3$	60.00				---	1.17	1.67	1.78	2.17	4.00	5.83	6.50	7.83	8.50	11.67	16.17	22.00
7 $A_2C_2D_1$	61.17					---	0.50	0.61	1.00	2.83	4.66	5.33	6.66	7.33	10.50	15.00	20.83
8 $A_3C_1D_3$	61.67						---	0.11	0.50	2.33	4.16	4.83	6.16	6.83	10.00	14.50	20.33
9 $A_3C_1D_2$	61.78							---	0.39	2.22	4.05	4.72	6.05	6.72	9.89	14.39	20.22

Note: $p < .05$ for all differences ≥ 4.15

$p < .01$ for all differences ≥ 4.83

Table 3, Continued

INTERACTIONS			3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		MEANS	57.33	57.83	59.72	60.00	61.17	61.67	61.78	62.17	64.00	65.83	66.50	67.83	68.50	71.67	76.17	82.00
10	$A_3C_1D_1$	62.17								---	1.83	3.66	4.33	5.66	6.33	9.50	14.00	19.83
11	$A_1C_2D_3$	64.00									---	1.83	2.50	3.83	4.50	7.67	12.17	18.00
12	$A_3C_2D_1$	65.83										---	0.67	2.00	2.67	5.84	10.34	16.17
13	$A_1C_2D_2$	66.50											---	1.33	2.00	5.17	9.67	15.50
14	$A_1C_2D_1$	67.83												---	0.67	3.84	8.34	14.17
15	$A_1C_1D_3$	68.50													---	3.17	7.67	13.50
16	$A_1C_1D_2$	71.67														---	4.50	10.33
17	$A_2C_1D_1$	76.17															---	5.83
18	$A_1C_1D_1$	82.00																---

Note: $p < .05$ for all differences ≥ 4.15

$p < .01$ for all differences ≥ 4.83

TABLE 4

AGREEMENT OF INITIAL RESPONSES, CORRECT RESPONSES AND EYE MOVEMENTS

Subject	All Agreement	Not All Agreement	p	r_m
1	243	194	< .001	.58
2	185	128	< .001	.78
3	203	152	< .001	.80

significant. It also showed the laterality by end-segregation interaction not to be significant.

Discussion

The results of the present experiment indicate that an end-segregation effect is more apparent for the shorter as compared to the longer pattern lengths. However, all the response distributions obtained are not consistent with earlier predictions. Noting Harcum's (1964) findings, it was expected that the 4-element pattern would be so simple that a selective perceptual process would be unnecessary. It was also predicted that the 20- and 28-element patterns would produce response curves showing a minima of errors about foveal fixation.

A possible explanation for the lack of foveal facilitation found in the resulting response distributions might be due to errors of mislocation. This possibility is especially likely since the response templates used in the present study differed from those used in many previous studies in that there was no center marker on the response template corresponding to the fixation marker. Such a procedural difference apparently eliminated the Ss' most valuable reference point, thereby maximizing the possibility of errors of mislocation.

In discussing errors of mislocation, Derks, Cherry and Larson (1969) emphasize the importance of a "collapsing" stimulus. They suggest that if a pair of dots are perceived as a single element (collapsed stimulus), then all adjacent dots will be reported one position closer to the collapsed pair. Clearly, the absence of a center reference marker in the present study would optimize the probability of Ss' collapsing stimuli. That such a phenomenon is more prevalent among the centrally located elements is consistent with the present theoretical position of end-segregation.

Although responses to the 12- and 16-element patterns were also affected by the lack of a center marker, these patterns were responded to more accurately at their left end. These results corroborate previously reported data (*e. g.*, Harcum, 1964), and they lend further evidence for a "primacy effect" which scans the stimulus pattern from one end to the other. The stronger primacy effect for the 12- as compared to the 16-element patterns further suggests that response accuracy decreases as the amount of information to be reported increases. This interpretation is consistent with the formulations of Harcum and Rabe (1958).

The apparent lack of any such primacy effect for the patterns of 20- and 28-elements suggests two possibilities: either these patterns extended so far into peripheral vision that they had no perceivable ends to serve as reference points; or, they simply were too complex so that such a mechanism was unable to organize the stimuli effectively and aid in their retrieval. The lack of a primacy effect for the 28-element pattern agrees with Harcum's (1969) findings and the similar performance for the 20-element pattern suggests that this length is also too long for effective end-to-end scanning.

As predicted, the laterality factor in the present study was significant. The 12- and 16-element patterns contributed most to this significance with patterns of 4-, 20-, and 28-elements producing nearly equal performance on either side of fixation. The observed left-field superiority corroborates much previous research cited earlier (*e. g.*, Harcum and Dyer, 1962).

The finding indicating that there was no significant difference in error distributions between the different orders of presentation is not easily explained. Although it was not expected that there would be any differences between ascending and descending conditions, a difference between these conditions and that of the random presentation was expected. A possible cause of these results might be the accuracy of the S's fixation. In the present study, eye movements were monitored such that a stimulus was not presented until S was clearly ready and fixating. Ss were informed that their eye movements were being recorded, and they were instructed to remain fixating until the stimulus was presented. Given such stringent controls, it is assumed that the Ss maintained relatively accurate fixation. However, it is possible that the strict control of fixation accuracy was responsible for the lack of response differentiation among orders of presentation.

Another possible explanation for the lack of significant differences between orders of presentation might be the experimental sophistication of the Ss. Perhaps such well-experienced Ss believed it unnecessary to take advantage of the additional information made available in the ascending and descending conditions. In any case, after a few experimental sessions, boredom factors also might have reduced the effectiveness of a pre-exposure set.

The high agreement found between Ss' initial overt responses, number of correct responses, and eye movements, is consistent with earlier predictions. These data corroborate with results reported by Bryden (1960, 1961) and Crovitz and Daves (1962) which suggest that initial eye movements are made to the left of fixation and there is greater accuracy found here. The results are also consistent with White's (1970a) findings that fewer errors occur among those elements which were reported first in the response sequence (*i. e.*, those to the left of fixation). Although the present data suggest a high correlation between overt responses, number of correct responses and eye movements, they provide no information as to the causality of these phenomena.

EXPERIMENT II

Purpose of the Study

Experiment I utilized patterns of 28 elements as well as patterns of 4, 12, 16 and 20 elements in an investigation of the end-segregation effect. The 28-element pattern was used to study S's response to such a complex stimulus with a minimal predisposition or response set, as well as to replicate Harcum's (1969) findings. However, it should be realized that although Harcum's data and those reported in Experiment I clearly suggest that the very complex stimulus patterns eliminate end-segregation, there are two possible interpretations of these results, as previously noted. Either the end elements are not accurately reproduced because they are not seen due to sensitivity factors (i. e., their peripheral location), or perhaps these patterns are so complex that the more extreme elements are masked by one another.

Experiment II was designed to investigate if end elements of the five designated pattern lengths used in Experiment I could be reproduced when presented without interference from intervening stimulus elements. It was predicted that such elements would be reproduced with a minima of errors, certainly with fewer errors than are found among these same positions when many elements are presented within the same pattern length.

Method

Subjects

The Ss were thirteen right-handed women undergraduate students of

The College of William and Mary. Three of these Ss were those who participated in Experiment I. The remaining ten were experimentally naive. Each S was paid for her services and each had 20-20 vision or better.

Apparatus

The tachistoscope was identical to that used in Experiment I. However, the stimuli and the response-recording sheets were different.

The binary patterns were constructed by typewriting a horizontal row of four zeros on white stimulus cards and filling in one zero on either side of fixation such that each element position was blackened equally often. Each element was 13.2 in. through the horizontal diameter, with the space between the end elements subtending 17.6 in. Total lengths of patterns subtended from 1.9° for the 4-element pattern length to 13.4° for the 28-element pattern length. There were either 4, 12, 16, 20 or 28 element pattern lengths, each corresponding respectively to the pattern lengths used in Experiment I. Thus, the four elements always consisted of the two end elements, on either side of fixation, of each respective length. The binary patterns used are reproduced in Appendix A.

Procedure

Each pattern length was presented eight times. The presentation order of different lengths and patterns was designated according to a random numbers table with the restriction that no two lengths or patterns appeared succeedingly and each length appeared an equal number of times.

Before each session, Ss were asked to read an instruction sheet describing the experimental task (see Appendix B). Experimental sessions consisted of ten practice trials and forty test exposures. The second half of the exposures consisted of the first twenty targets turned upside-down and their respective mirror images presented. Sessions lasted approximately thirty minutes.

The Ss' fixational accuracy was maintained by instruction, and her eye movements were recorded as in Experiment I.

In order to minimize the possibility of any pre-exposure set on the part of Ss, response-recording templates were provided while Ss fixated on the center marker. Response templates contained a horizontal row of the presented pattern-length of 4 elements. Errors were scored as in Experiment I.

Results

The data were tabulated separately for the experimentally naive and experienced subjects. Mean proportion of correct responses were calculated for each pattern length at each element position. These proportions are presented in Tables 5 and 6.

As is shown in Table 5, fewer correct responses were made for stimuli of the 28-element pattern length than were made for any other pattern length. However, it should be noted that the .69 and .70 proportions found at these extreme positions are better than the .50 proportion that would be expected by chance. Similarly, Table 6 shows the experienced Ss responding to the 28-element pattern length with fewer proportion correct than on other pattern lengths. Again, proportions shown (.76 and .75) are above chance performance.

A comparison of Tables 5 and 6 shows that the practiced Ss do slightly better on the 28-element pattern length than do the less practiced Ss. However, this better performance is not consistent and in the 16- and 20-element pattern lengths the performance of the naive Ss

TABLE 5

MEAN PROPORTION CORRECT RESPONSES FOR EACH PATTERN LENGTH AT EACH ELEMENT POSITION FOR EXPERIMENTALLY NAIVE SUBJECTS (N = 10)

Number of Spaces	Element Position 1	2	3	4
4	.87	.87	.85	.85
12	.94	.94	.91	.91
16	.86	.86	.92	.92
20	.84	.84	.80	.80
28	.69	.69	.70	.70

TABLE 6

MEAN PROPORTION CORRECT RESPONSES FOR EACH PATTERN LENGTH AT EACH ELEMENT POSITION FOR EXPERIENCED SUBJECTS (N = 3)

Number of Spaces	Element Position 1	2	3	4
4	.96	.96	.91	.91
12	1.0	1.0	.96	.96
16	.96	.96	.79	.79
20	.83	.83	.79	.79
28	.76	.76	.75	.75

surpasses that of the experienced Ss.

It should be noted also that both groups performed best with the 12-element pattern lengths.

Discussion

The findings of the present experiment suggest that the Ss are capable of seeing the extreme positions of each pattern length employed in Experiment I. Thus, the implicit supposition made by Harcum (1969) is supported.

Although the data indicate that most extreme stimuli are responded to with fewest correct responses, responding behavior does not consistently improve as the pattern length decreases. Indeed, the 12-element length is reproduced most accurately by both groups of Ss. Such responding behavior suggests that sensitivity factors are not determining which elements are most accurately reproduced. Thus, the data are consistent with the general theoretical position taken in this paper.

The findings of Experiment I which indicate no end-segregation for the 20- and 28-element patterns may not be attributed to Ss' inability to see the end elements. Rather, a more consistent interpretation suggests that poor response performance for these end elements is due to the complexity of the stimulus array.

EXPERIMENT III

Purpose of the Study

The proportion correct distributions for the 28-element patterns in Experiment I indicated completely haphazard performance. Such results did not agree with predictions made in light of Harcum's (1969) findings in which he used identical stimulus patterns.

It was reasoned that an explanation of the data might be that Harcum's Ss responded on templates which had a small "+" marker located in the center of the response pattern whereas Ss in Experiment I had no such center marker. Thus, it was possible that because of a lack of reference point on the response template corresponding to the fixation point on the stimulus pattern, Ss were unable to localize their responses.

Experiment III was designed to test the hypothesis that Experiment I was unable to replicate Harcum's (1969) findings due to a procedural difference, i. e., no center marker on the response sheet. Thus, in Experiment III the response-recording sheets consisted of a row of twenty-eight blank zeros bisected by a small "+," which represented the fixation cross. Using this type of response form, it was hypothesized that resulting distributions of proportion correct responses as a function of element position would show an increase in correct responses near foveal fixation.

Method

Subjects

The Ss were thirteen right-handed women undergraduate students of The College of William and Mary. Three of these Ss were those who participated in both Experiments I and II. The remaining ten Ss were experimentally naive. Each S was paid for her services and each had 20-20 vision or better.

Apparatus

The tachistoscope and the 28-element patterns were identical to those used in Experiment I. However, the response-recording sheets differed in that the row of 28 zeros was bisected by a small "+," which represented the fixation cross.

Procedure

The 28-element patterns were presented exactly as they were presented in the sequential condition of Experiment I. Before each session, Ss were asked to read an instruction sheet describing the experimental task (see Appendix B). Experimental sessions consisted of ten practice trials and forty test exposures. Sessions lasted approximately forty minutes.

Procedures concerning eye movement recordings and scoring were identical to those of Experiment I.

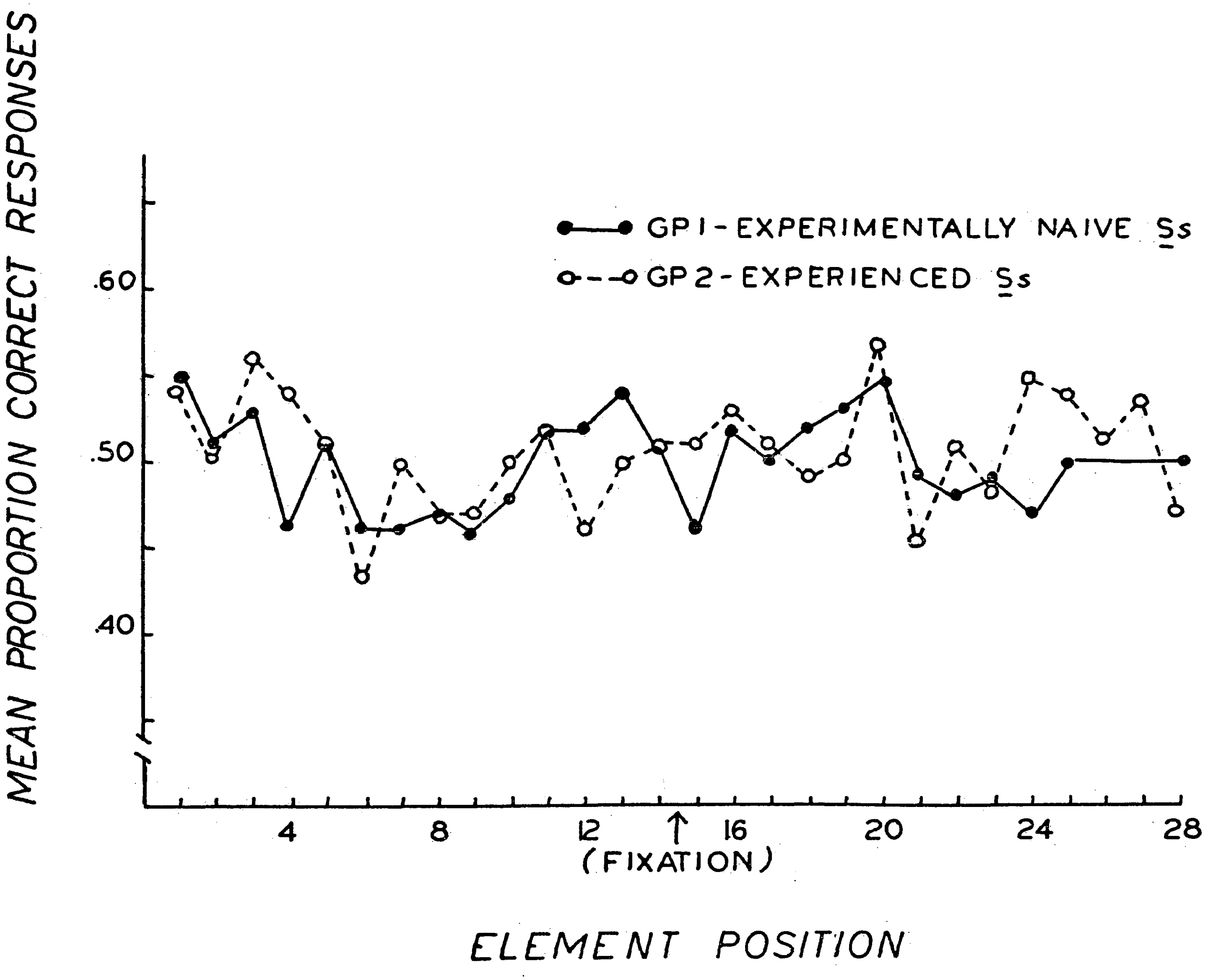
Results

The data were plotted separately for the experimentally naive and experienced Ss. Figure 6 shows the mean proportion of correct responses at each element position for both groups of Ss. It is apparent from this figure that neither group of Ss responded differentially for any given element positions. The curves indicate chance performance.

Figure 7 shows the mean proportion of errors of commission at each element position for both groups. This figure clearly indicates

FIGURE 6

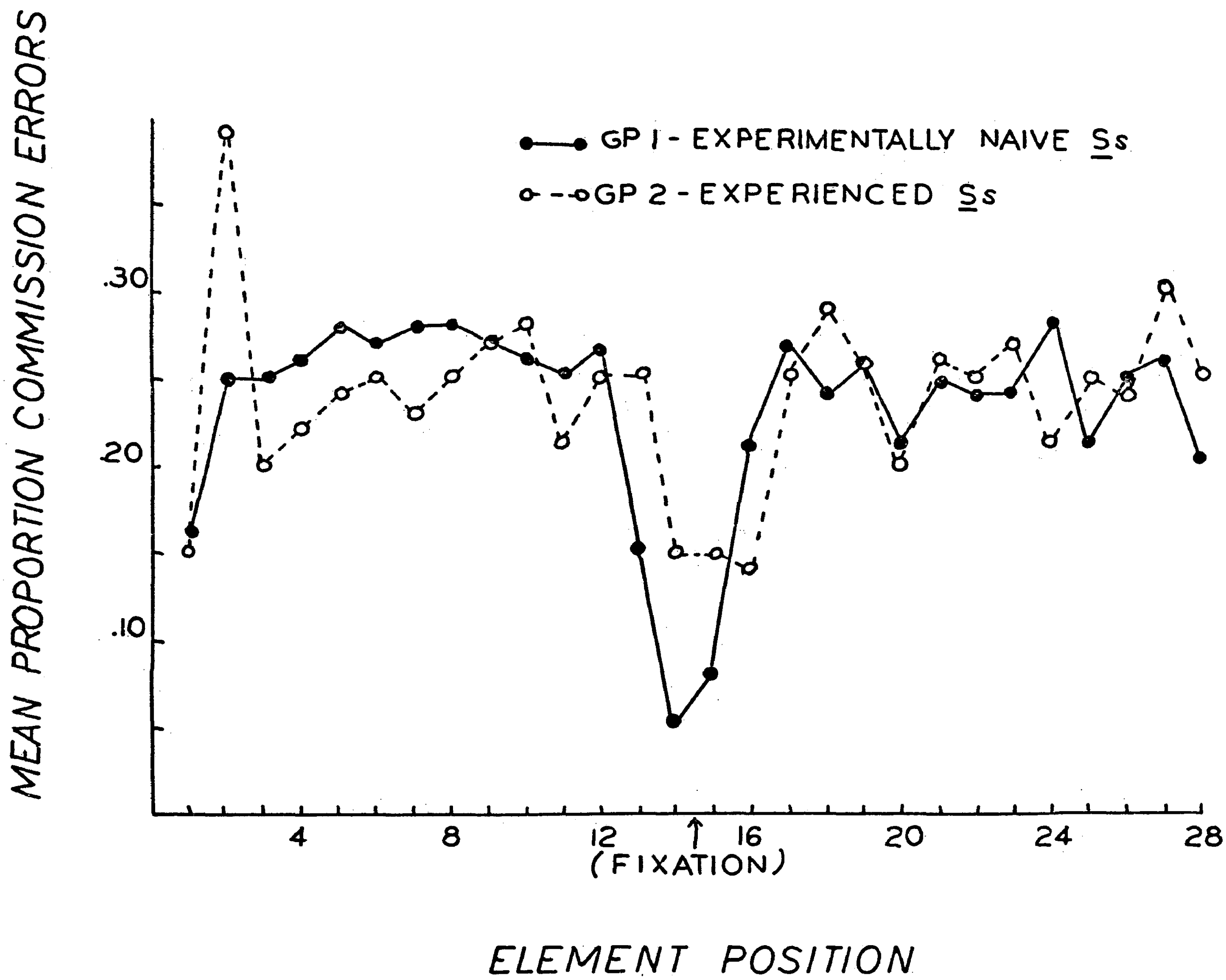
MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION



GP1 - EXPERIMENTALLY NAIVE $\underline{S}$s
GP2 - EXPERIENCED $\underline{S}$s
MEAN PROPORTION CORRECT RESPONSES
.60
.50
.40
4
8
12
16
20
24
28
(FIXATION)
ELEMENT POSITION

FIGURE 7

MEAN PROPORTION COMMISSION ERRORS AT EACH ELEMENT POSITION



MEAN PROPORTION COMMISSION ERRORS
GP 1 - EXPERIMENTALLY NAIVE Ss
GP 2 - EXPERIENCED Ss
.30
.20
.10
4
8
12
16
20
24
28
(FIXATION)
ELEMENT POSITION

that the Ss were responding less to the center 4 binary elements. Although this effect is shown for both groups of Ss, the naive Ss responded less at these positions than did the experienced Ss.

Discussion

The mean proportion of correct responses suggests chance performance at all element positions. Such results are clearly inconsistent with the prediction that there would be an increase in correct responses about foveal fixation.

Upon inspection of the error distribution curves, in which errors of commission were tabulated and plotted separately, it was noted that Ss were not responding to the foveally located stimuli. Such responding behavior is incongruous with the theoretical arguments made above as well as contrary to any common sense notion of what might be expected.

The relative absence of correct responses as well as errors of commission among center elements suggested that for some reason, either Ss were not seeing these elements, or, if they were seeing them, they were not responding correctly. A possible cause for such a phenomenon seemed to lie in a temporal masking due to the fixation marker.*

*Peter L. Derks--personal communication.

EXPERIMENTS IV AND V

Purpose of the Studies

Both Experiments I and III yielded proportion correct distributions for the 28-element patterns which indicated chance performance. Predictions made from Harcum's (1969) results in which he used identical stimuli, find no support in these data. Nor do they support the hypothesis in Experiment III which suggested that the chance performance found in Experiment I was due to Ss' not having a reference point on the response sheet corresponding to the fixation marker.

Experiments IV and V were designed to investigate the possibility that the negative results found in Experiments I and III, utilizing 28-element pattern lengths, might be explained in terms of a temporal masking caused by the fixation marker. Thus, the present experiments utilized a much smaller fixation marker so as to minimize the possibility of such a masking effect.

Method: Experiment IV

Subjects

The Ss were eight right-handed women undergraduate students of The College of William and Mary. Three of these Ss were those who participated in Experiments I, II and III. The remaining five Ss were experimentally naive. Each S was paid for her services and each had 20-20 vision or better.

Apparatus

The tachistoscope, the 28-element patterns and the response-recording sheets were identical to those used in Experiment III. However, the fixation marker in the present experiment was a very small "x" consisting of two 2 mm lines located in the center of the pre-exposure field (the previous fixation marker consisted of two 5 mm lines).

Procedure

The procedures followed were identical to those of Experiment III.

Method: Experiment V

Subjects

The Ss were eight right-handed women undergraduate students of The College of William and Mary. Three of these Ss were those who participated in the previous four experiments. The remaining five Ss were experimentally naive. Each S was paid for her services and each had 20-20 vision or better.

Apparatus

The tachistoscope, and the 12-element stimulus patterns were identical to those used in the Sequential Condition of Experiment I. The fixation marker was identical to that used in Experiment IV. The response-recording sheet patterns consisted of twelve zeros bisected by a small "+" marker.

Procedure

The procedures followed were identical to those of Experiments III and IV.

Results

The data from Experiments IV and V were analyzed together. The results showed that the length of the pattern and eccentricity were significant factors. The size of the fixation marker was found to significantly interact with both pattern length and eccentricity. It was also found that both laterality and end-segregation were significant factors. These also interacted significantly.

Figure 8 presents the mean proportion of correct responses, at each of the 28-element positions for group 2 (the experienced Ss) and for group 3 (the experimentally naive Ss). (Also presented in this figure is the response distribution to the 28-element pattern obtained in Experiment I. Group 1 consists of the experienced Ss performing with a large fixation marker.) As is apparent in Figure 8, both groups 2 and 3 performed considerably better to the center stimuli than did group 1.

Figure 9 presents the mean proportion of correct responses, at each of the 12-element positions, for group 2 (the experienced Ss) and for group 3 (the experimentally naive Ss). (Also presented in this figure is the response distribution to the 12-element pattern obtained in Experiment I. Group 1 consists of the experienced Ss performing with a large fixation marker.) As is also apparent in Figure 9, both groups 2 and 3 performed considerably better to the center stimuli than did group 1.

A three factor, factorial analysis of variance was performed on the mean proportion of correct responses at different element positions. This first analysis considered the responses of the experienced Ss to the 12- and 28-element patterns under both the small and large fixation marker conditions. The three factors tested were: size of the fixation marker (A), pattern length (B), and eccentricity (C). Table 7 presents the summary table for this analysis. As can be seen from this table, pattern length was a significant variable ($F_{1, 2} = 30.84$, $p < .05$, $r_m > .9$). A significantly larger proportion of

FIGURE 8

MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION

FOR THE 28-ELEMENT PATTERN

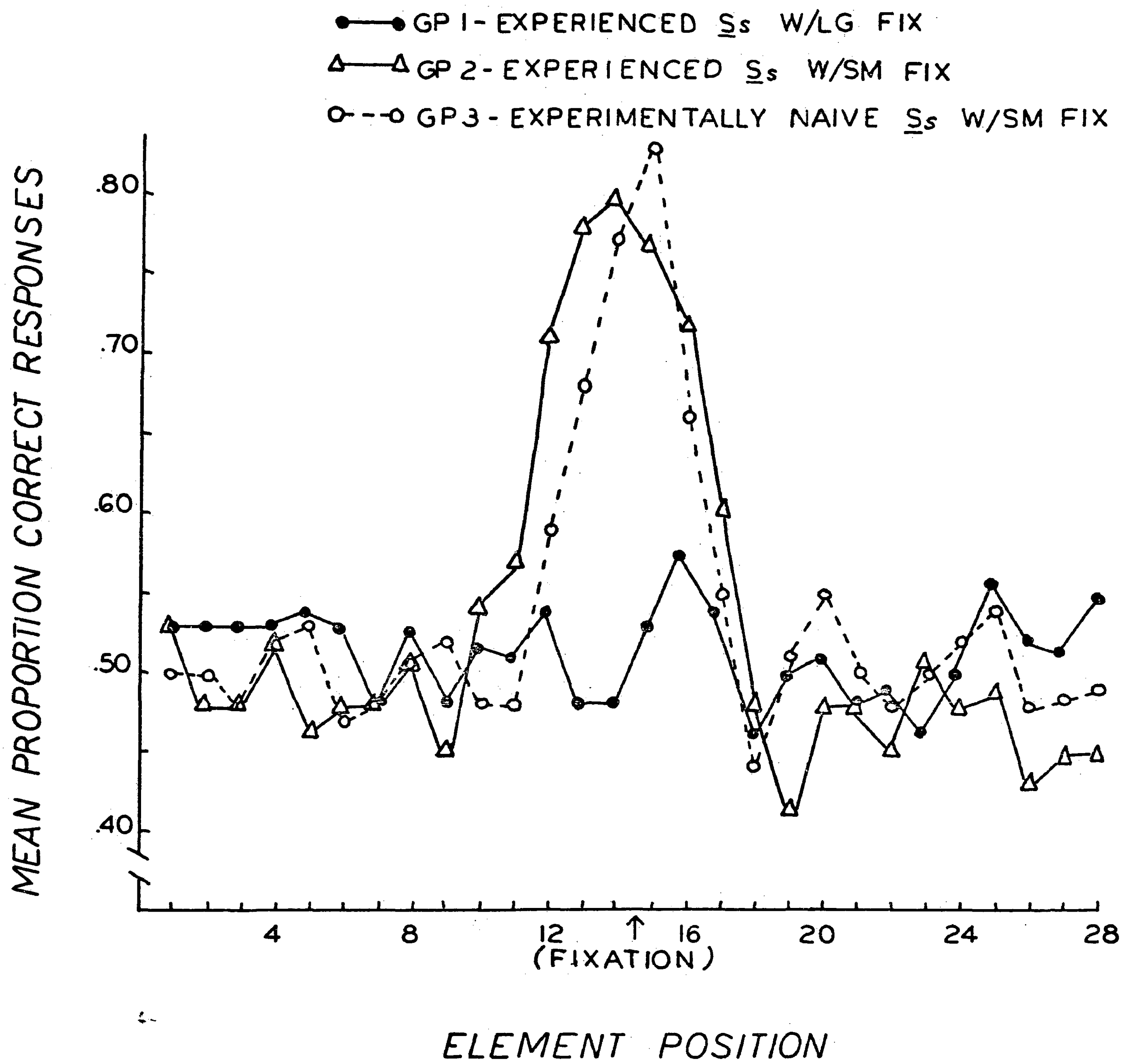

GP 1 - EXPERIENCED Ss W/LG FIX
GP 2 - EXPERIENCED Ss W/SM FIX
GP 3 - EXPERIMENTALLY NAIVE Ss W/SM FIX
MEAN PROPORTION CORRECT RESPONSES
.80
.70
.60
.50
.40
4
8
12
16
20
24
28
(FIXATION)
ELEMENT POSITION

FIGURE 9

MEAN PROPORTION CORRECT RESPONSES AT EACH ELEMENT POSITION

FOR THE 12-ELEMENT PATTERN

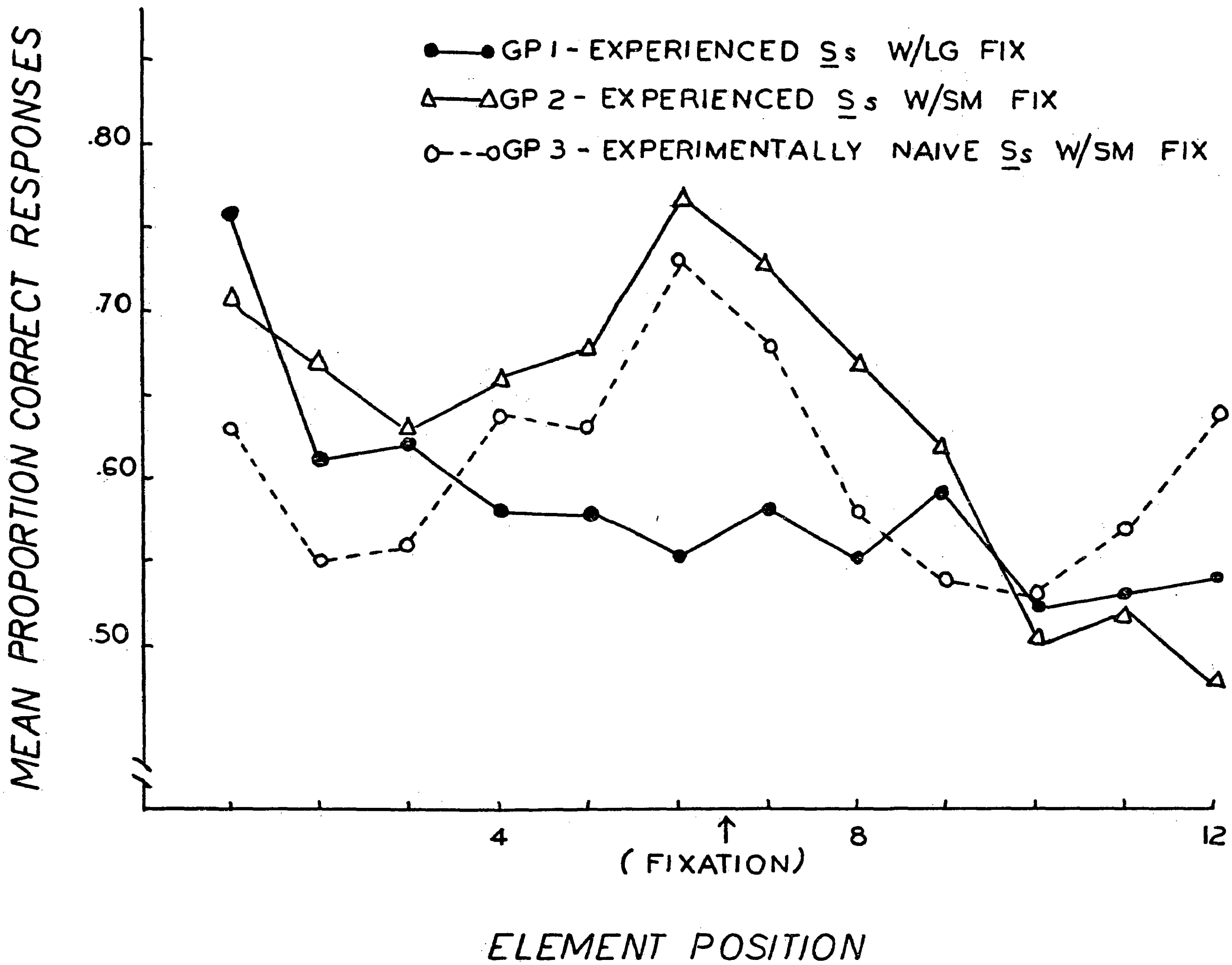

GP 1 - EXPERIENCED Ss W/LG FIX
GP 2 - EXPERIENCED Ss W/SM FIX
GP 3 - EXPERIMENTALLY NAIVE Ss W/SM FIX
MEAN PROPORTION CORRECT RESPONSES
.80
.70
.60
.50
4
8
12
(FIXATION)
ELEMENT POSITION

TABLE 7

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR SIZE OF FIXATION MARKER, PATTERN LENGTH, AND ECCENTRICITY

Source	df	MS	F
Subjects	2		
Size of Fixation Marker (A)	1	75.44	4.11
Error	2	18.37	
Pattern Length (B)	1	112.25	30.84 $p < .05$
Error	2	3.64	
Eccentricity (C)	5	72.75	7.00 $p < .01$
Error	10	10.39	
A X B	1	1.30	.31
Error	2	4.24	
A X C	5	47.25	4.65 $p < .05$
Error	10	10.17	
B X C	5	24.99	4.44 $p < .05$
Error	10	5.63	
A X B X C	5	9.67	1.34
Error	10	7.23	
Total	71		

correct responses was made to the 12-element pattern.

As shown in Table 7, the eccentricity (C) factor was also significant ($F_{5,\ 10} = 7.00$, $p < .01$, $r_m > .9$). This factor consists of three mean scores on either side of fixation. The first mean score consists of correct responses to the two left-end element positions; the second consists of correct responses to elements between the two left-end elements and the two elements to the immediate left of fixation; and the third mean score consists of correct responses to the two elements to the immediate left of fixation. Mean scores to the right of fixation were derived in a like manner. Figure 10 presents the mean proportion correct responses for different eccentricities. It is clear from this curve that the centrally located elements were responded to most accurately. The end elements were reproduced least accurately with performance on the left end slightly better than that on the right.

Multiple t-tests were performed comparing differences between mean correct responses. The t-values for all possible comparisons are presented in Table 8. As shown in this table, responses to the two elements on either side of fixation are significantly different from both the right-center elements ($t_{10} = 4.14$ and 3.92, $p < .01$) and the right-end elements ($t_{10} = 4.39$ and 4.17, $p < .01$), respectively. Responses to the left-end elements and the left-center elements also significantly differed from those to the two elements to the left of fixation ($t_{10} = 2.46$ and 2.42, $p < .05$). It is also apparent that responses to the left-end elements significantly differed from those to the two elements to the right of fixation ($t_{10} = 2.24$, $p < .05$).

Table 7 also shows that the size of the fixation marker (A) significantly interacted with eccentricity (C) ($F_{5,\ 10} = 4.65$, $p < .05$,

FIGURE 10

MEAN PROPORTION CORRECT RESPONSES AT DIFFERENT ECCENTRICITIES

FOR BOTH PATTERN LENGTHS

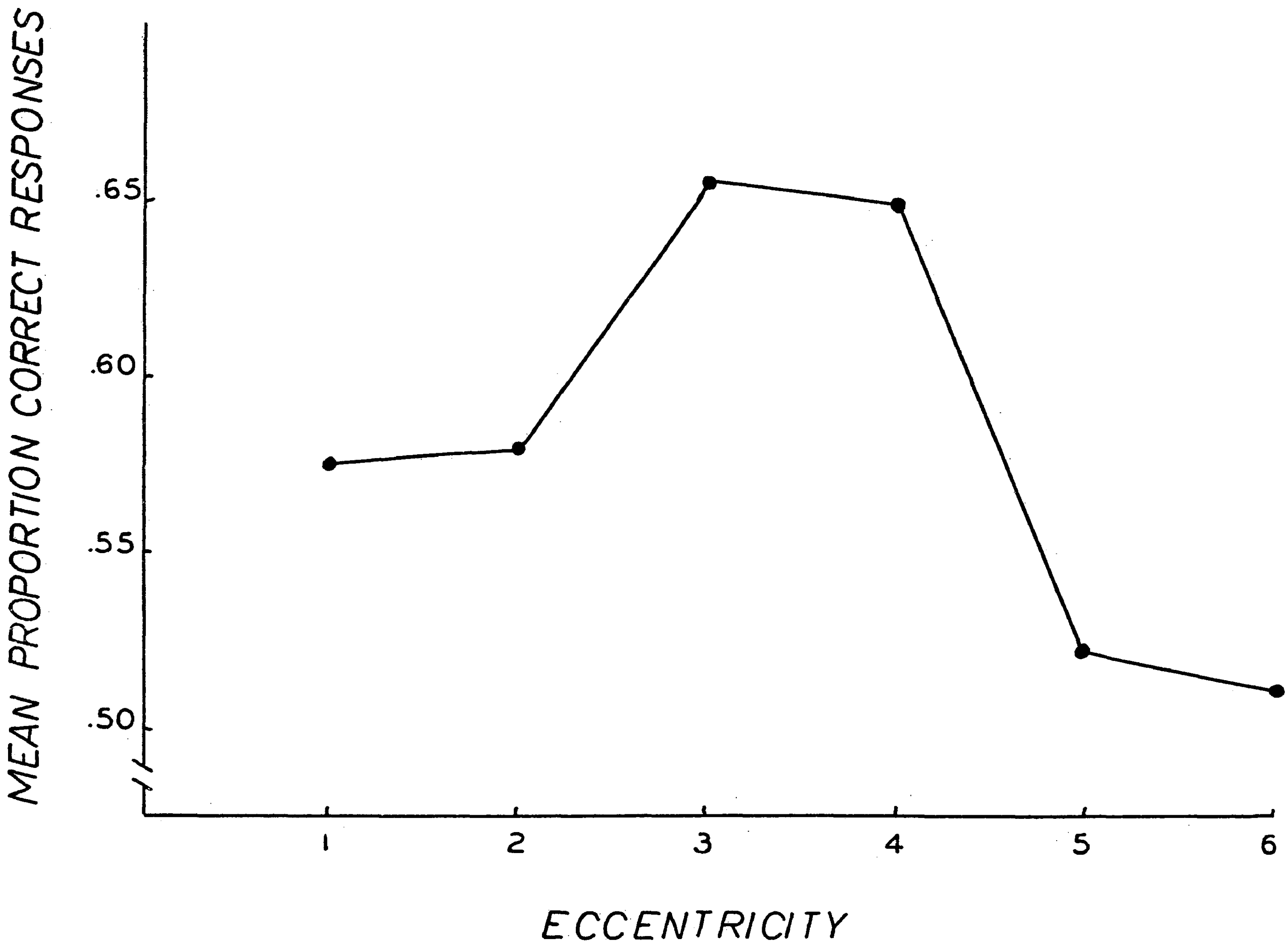

MEAN PROPORTION CORRECT RESPONSES
.65
.60
.55
.50
1
2
3
4
5
6
ECCENTRICITY

TABLE 8

† VALUES COMPARING DIFFERENCES BETWEEN LEVELS OF ECCENTRICITY (C_1-C_6)

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	----	.045	2.46*	2.24*	1.68	1.92
C_2		----	2.42*	2.19	1.73	1.97
C_3			----	.219	4.14**	4.39**
C_4				----	3.92**	4.17**
C_5					----	.242
C_6						----

*$p < .05$
**$p < .01$

$r_m > .9$). Multiple t-tests were performed comparing differences between mean correct responses at levels of A and C. The t-values for all possible comparisons are presented in Table 9. It is apparent from this table that the most significant differences are between the center four elements, with the small fixation marker. There are also some significant differences between the center elements and the right-end elements with the small fixation marker.

The pattern length (B) by eccentricity (C) interaction is also significant ($F_{5, 10} = 4.44$, $p < .05$, $r_m > .9$). Multiple t-tests were performed comparing differences at levels of B and C. The t-values for all possible comparisons are presented in Table 10.

A second three factor, factorial analysis of variance was performed on the mean proportion of correct responses at different element positions. This analysis considered the responses of experimentally naive Ss to the 12-element and the 28-element patterns using a small fixation marker. The three factors tested were: pattern length (A), laterality (B) and end-segregation (C). Table 11 presents the summary table for this analysis.

As shown in Table 11, the laterality (B) factor was significant ($F_{1, 8} = 11.95$, $p < .01$, $r_m > .75$). There were significantly more correct responses made to elements to the left of fixation as compared to the right. The end-segregation (C) factor is also significant ($F_{2, 16} = 10.95$, $p < .01$, $r_m > .75$). This factor considered three mean scores. The first consisted of correct responses to the two left-end elements. The second consisted of correct responses to elements between the two left-end and the two right-end elements and the third mean consisted of correct responses to the two right-end elements. Multiple t-tests were

TABLE 9

t VALUES COMPARING DIFFERENCES BETWEEN LEVELS OF FIXATION MARKER

(A_1- large marker, A_2- small marker) AND ECCENTRICITIES (C_1- C_6)

	A_1C_1	A_1C_2	A_1C_3	A_1C_4	A_1C_5	A_1C_6	A_2C_1	A_2C_2	A_2C_3	A_2C_4	A_2C_5	A_2C_6
A_1C_1	----	.418	.092	.543	.717	.136	.902	.554	4.35**	3.58**	2.04	1.72
A_1C_2		----	.326	.125	1.16	.554	.483	.136	3.93**	3.16*	1.62	2.14
A_1C_3			----	.451	.809	.228	.809	.462	4.26**	3.48**	1.94	1.82
A_1C_4				----	1.26	.679	.359	.011	3.80**	3.03*	1.49	2.27*
A_1C_5					----	.582	1.62	1.27	5.06**	4.29**	2.76*	1.01
A_1C_6						----	1.04	.690	4.48**	3.71**	2.17	1.59
A_2C_1							----	.348	3.44**	2.67*	1.14	2.63*
A_2C_2								----	3.79**	3.02*	1.48	2.28*
A_2C_3									----	.772	2.31*	6.07**
A_2C_4										----	1.54	5.30**
A_2C_5											----	3.76**
A_2C_6												----

$^*p < .05$
$^{**}p < .01$

TABLE 10

† VALUES COMPARING DIFFERENCES BETWEEN LEVELS OF PATTERN LENGTH

(B_1 - 12 elements, B_2 - 28 elements) AND ECCENTRICITY (C_1 - C_6)

	B_1C_1	B_1C_2	B_1C_3	B_1C_4	B_1C_5	B_1C_6	B_2C_1	B_2C_2	B_2C_3	B_2C_4	B_2C_5	B_2C_6
B_1C_1	----	.854	.058	.423	3.40**	4.38**	5.23**	4.29**	.423	.489	5.06**	4.56**
B_1C_2		----	.795	.431	2.54*	3.53**	4.37**	3.44**	.431	.365	4.20**	3.71**
B_1C_3			----	.365	3.34**	4.32**	5.17**	4.23**	.365	.431	5.00**	4.50**
B_1C_4				----	2.98*	3.96**	4.80**	3.87**	.000	.066	4.64**	4.14**
B_1C_5					----	.978	1.82	.891	2.98*	2.91*	1.66	1.16
B_1C_6						----	.847	.088	3.96**	3.89**	.679	.182
B_2C_1							----	.934	4.80**	4.74**	.168	.664
B_2C_2								----	3.87**	3.80**	.766	.270
B_2C_3									----	.066	4.64**	4.14**
B_2C_4										----	4.57**	4.07**
B_2C_5											----	.496
B_2C_6												----

*$p < .05$
**$p < .01$

TABLE II

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR PATTERN LENGTH, LATERALITY AND END-SEGREGATION

Source	df	MS	F
Between Subjects	9		
Pattern Length (A)	1	47.52	3.27
Subjects Within Groups	8	14.53	
Within Subjects	50		
Laterality (B)	1	16.01	11.95 $p < .01$
A X B	1	.83	.62
B X Subjects Within Groups	8	1.34	
End-Segregation (C)	2	67.88	10.95 $p < .01$
A X C	2	19.42	3.13
C X Subjects Within Groups	16	6.20	
B X C	2	141.39	9.03 $p < .01$
A X B X C	2	25.74	1.64
B X C X Subjects Within Groups	16	15.65	
Total	59		

performed to investigate the differences between these means and they showed that correct responses to the middle elements were significantly greater than those to the left-end elements ($t_{16} = 6.53$, $p < .01$) and to those of the right-end elements ($t_{16} = 7.28$, $p < .01$).

It is also apparent in Table 11 that there is a significant interaction ($F_{2, 16} = 9.03$, $p < .01$, $r_m > .7$) between the laterality (B) and end-segregation (C) factors. Multiple t-tests were performed to compare the means involved in this interaction. Table 12 presents t-values for all possible comparisons among these means.

Discussion

28-Element Pattern

The findings of the present experiments clearly support the interpretation of the results found in Experiments I and III which suggests that the obtained response distributions were caused by a temporal masking due to the large fixation marker. This temporal masking is probably enhanced by spatial masking in which the outlines of all elements mutually inhibit one another. Such an interpretation is consistent with Woodworth and Schlosberg's (1954) formulations.

When a smaller fixation marker was employed the response accuracy for the foveally located elements of the 28-element pattern increased appreciably. However, it should be noted that although response accuracy for the foveally located stimuli increased, responses to the more extreme elements remained symmetrical and at chance performance.

The replication of the effect of foveal facilitation and the elimination of end-to-end scanning with the 28-element pattern, using naive Ss, indicates that such a response distribution is not unique to the well-practiced Ss used in the previous experiments. Rather, it suggests

TABLE 12

t VALUES COMPARING DIFFERENCES BETWEEN LEVELS OF LATERALITY (B_1- left, B_2- right) AND END-SEGREGATION (C_1- left, C_2- middle, C_3- right)

	B_1C_1	B_1C_2	B_1C_3	B_2C_1	B_2C_2	B_2C_3
B_1C_1	----	.073	3.53**	2.40*	.746	.197
B_1C_2		----	3.45**	2.33*	.819	.124
B_1C_3			----	1.13	4.28**	3.33**
B_2C_1				----	3.15**	2.20*
B_2C_2					----	.944
B_2C_3						----

*$p < .05$
**$p < .01$

that Ss are unable to use any mechanism of end-to-end scanning because the complexity of the stimulus renders the ends of the pattern virtually beyond the range of effective vision. Since there were, in effect, no ends which could serve as reference points, Ss were left with the fixation marker as their only reference point. Presumably, the hypothesized scanning mechanism has no directionality from the center reference marker and thus laterality differences in responding are eliminated. Harcum (1969) hypothesizes that perceptual results, such as those obtained in the present study, should be similar to those obtained with the presentation of all elements entirely to either the left or right of fixation in separate exposures (Camp and Harcum, 1964). Indeed, the present findings substantiate these predictions and show equality of errors to the left and right of fixation.

Although the results corroborate Harcum's (1969) findings, both groups performing with a small fixation marker show a stronger foveal facilitation than did Harcum's Ss. It is not difficult to explain this stronger effect; Ss in the present experiments had more stringent controls on their fixation accuracy than Ss in previous studies. Thus, it is reasonable to assume that because of these controls the Ss were more likely to be attending to fixation upon stimulus presentation. Indeed, this was a necessary condition for stimulus presentation.

Klemmer's (1953) findings are also consistent with those of the present study. He obtained similar response distribution curves by using binary lights and poststimulus cues. However, his results differed in that he found greater accuracy, especially for the extreme left elements as compared to those on the extreme right.

12-Element Pattern

The response distributions obtained for the 12-element pattern were also affected by the size of the fixation marker. Clearly, the foveally located elements were responded to more accurately with the smaller marker. However, accuracy for these elements was not as great as it was in the longer pattern length. This suggests that because the 28-element pattern had no other reference points besides the fixation marker, the S's attention was concentrated more on this center marker than it was for that of the shorter patterns.

It also should be noted that the end-to-end scanning of the 12-elements was not detrimentally affected by the smaller fixation marker. Indeed, performance on nearly all element positions was improved with the smaller marker. This suggests that the additional reference point makes all the information present in the 12-element pattern more amenable for processing in short term memory. These results corroborate White's (1970b) predictions that stimuli appearing at the ends of a line and in foveally proximate positions will establish stronger memory traces than stimuli in intermediate positions.

GENERAL DISCUSSION AND CONCLUSIONS

Mneumonic Factors

The foregoing experiments corroborate previous findings (e. g., Harcum, 1964) that suggest mnemonic rather than sensitivity factors are responsible for a S's accuracy in the reproduction of binary patterns. Response distributions to different pattern lengths indicate that the processes of information translation and storage are contingent upon a number of such factors which are interdependent.

The general phenomenon studied was that of end-segregation--the tendency to perceive end elements more accurately due to their relatively unique positions. This effect was demonstrated in Experiment I for pattern lengths containing 4, 12, and 16 elements. The effect was shown to be more apparent for the shorter pattern lengths and it was eliminated for pattern lengths containing 20 and 28 elements.

The mechanism of end-segregation, as discussed previously, consists of a process of scanning a swiftly fading perceptual trace. This process proceeds in a manner of hypothesized eye fixations which organize groups of elements for storage in short term memory. Scanning generally proceeds from left to right because of certain habits acquired during reading. This process renders a primacy effect favoring elements to the extreme left of fixation.

However, end-segregation is not the sole determiner of response accuracy. Experiments IV and V demonstrated that with a smaller fixation marker, Ss tend to respond more accurately to those elements located at foveal fixation. Such foveal facilitation is shown in a decrease in errors to the four elements adjacent to fixation. Because this effect parallels both perceptual acuity gradients and cone density in the retina, it is tempting to attribute it to sensitivity factors. Camp (1961) suggests such a purely physiological explanation of foveal facilitation.

The present orientation, however, purports that foveal facilitation can also be explained in terms of mnemonic organizational factors. Clearly, when a S is presented with a stimulus array he attempts to organize the elements as accurately and as quickly as possible. Reference points facilitate such organization and, in the moderately complex patterns (e. g. those of 12 and 16 elements), end elements serve as such reference points. In the more complex patterns (e. g. those of 20 and 28 elements), end elements are less clear due to the complexity of the array and thus their contribution as reference points is minimal, if it exists at all. Such an explanation is consistent with the findings of Experiment II which suggest that the retinal location of these end elements is within the span of effective vision.

It appears that Ss' strategy of information analysis shifts as a function of pattern length. For the longer patterns, in which end-to-end scanning has been made very difficult, the only available reference point is the fixation marker which corresponds to the center marker on the response template. This marker thus becomes the sole reference point in the organizational process of short term memory. Such an interpretation suggests that it is the fixation marker's function as a reference point which produces foveal facilitation. When this marker is the only available reference point, it is maximally effective. However, when other reference points (e. g. end elements) are available, Ss selectively attend to elements adjacent to each of these, and response distributions reflect this attention. The results of Experiments IV and V are consistent with such an interpretation.

Order of Report and Eye Movements

The conclusion that Ss' processes of information-translation shift as a function of pattern length is consistent with the present data on the order of report. It was observed that Ss tended to respond on the shorter patterns from their left ends toward their right ends. However, initial responses to the 20- and 28-element patterns clustered about fixation and responses to more extreme elements were haphazard. These findings corroborate those of Harcum (1969). The analysis of eye movements is also consistent with the present interpretation.

Masking Phenomena

Two distinct masking problems were encountered in the foregoing experiments. The first concerned the mutual interference or confusability of the elements with one another. As Woodworth and Schlosberg (1954) suggest, this could be due to border inhibition effects or localization factors in which the difficulty of the reproduction of the inner elements lies in the problem of localizing them correctly within the total array.

The present experiments suggest that such localization problems become more apparent with increases in array length. When the size of an array exceeds S's capacity, items must be processed serially from a decaying perceptual trace (Kahnemen, 1969; Sperling, 1960, 1963). Kahnemen (1969) suggests that the probability that a given item has been processed is inversely related to the number of items in the array. Clearly, the more embedded elements in the longer patterns are more vulnerable to this masking effect and their relative vulnerability increases with the decay of the neural trace.

The second masking problem encountered was that produced by the large fixation marker. This masking phenomenon was studied in Experiments IV and V. The data obtained can be explained by integration and/or interruption theories of visual masking.

An integration approach to visual masking would assume that the binary array and the large fixation marker are linearly summed and that the response to their presentation in sequence is the same as would be evoked by their joint simultaneous presentation. Here the temporal range of masking corresponds to the range of temporal summation (Kahnemen, 1969). Conversely, an interruption theory explanation would suggest that the fixation marker interrupts the consolidation of the percept of the binary pattern. Such an interpretation is consistent with Lindsley's (1961) formulations.

In any case, it is apparent that visual masking is responsible for the response distributions obtained with the large fixation marker. The present data do not provide information as to which of the above theories better accounts for results reported here.

APPENDIX A

BINARY PATTERNS

RANDOM PATTERNS USED IN EXPERIMENT I

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● ○ ○ ○ ● ○ ● ● ● ○ ○ ● ● ○ ○ ● ● ● ○ ○

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● ○ ○ ○ ● ● ○ ● ○ ● ○ ● ○ ○ ● ○ ● ● ● ○

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● ○ ● ○

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APPENDIX A (cont'd)

4-ELEMENT PATTERNS USED IN EXPERIMENT I	12-ELEMENT PATTERNS USED IN EXPERIMENTS I AND V
● ○ ○ ●	○ ● ● ○ ● ○ ● ● ○ ○ ○ ●
○ ● ○ ●	○ ● ● ○ ○ ● ○ ○ ● ● ○ ●
○ ● ● ○	○ ○ ● ● ● ○ ● ○ ● ○ ○ ●
● ○ ● ○	○ ○ ● ● ○ ● ○ ○ ● ● ○ ●
○ ● ○ ●	● ○ ○ ● ● ○ ● ● ● ○ ○ ○
● ○ ○ ●	○ ● ○ ● ○ ● ● ● ○ ○ ● ○
○ ● ○ ●	○ ● ○ ● ○ ● ○ ● ○ ○ ● ●
○ ● ● ○	○ ● ● ○ ● ○ ○ ● ● ○ ○ ●
○ ● ○ ●	● ○ ● ○ ● ○ ○ ● ● ● ○ ○
● ○ ● ○	○ ● ● ○ ○ ● ○ ● ○ ○ ● ●
● ○ ○ ●	● ○ ● ○ ● ○ ● ○ ● ○ ○ ●
○ ● ○ ●	○ ● ○ ● ○ ● ● ● ○ ○ ○ ●
● ○ ● ○	● ○ ● ○ ● ○ ● ○ ○ ● ● ○
○ ● ● ○	● ○ ○ ○ ● ● ● ○ ● ● ○ ○
● ○ ○ ●	○ ● ● ● ○ ○ ○ ● ● ○ ○ ●
● ○ ● ○	● ○ ● ○ ● ○ ● ● ● ○ ○ ○
○ ● ● ○	● ● ○ ○ ○ ● ● ○ ● ○ ○ ●
○ ● ○ ●	○ ● ● ○ ● ○ ○ ● ○ ○ ● ●
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APPENDIX A (cont'd)

16-ELEMENT PATTERNS USED IN EXPERIMENT I

● ○ ○ ● ○ ● ● ○ ● ○ ○ ● ○ ● ○ ●

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● ○ ○ ● ● ○ ● ○ ● ○ ○ ● ○ ● ● ○

● ○ ○ ● ○ ● ○ ● ● ● ○ ● ○ ○ ○ ●

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○ ● ○ ● ○ ● ○ ● ○ ● ○ ● ○ ● ○ ●

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APPENDIX A (cont'd)

20-ELEMENT PATTERNS USED IN EXPERIMENT I

O O ● ● ● O O ● ● O O ● O O O ● O ● ● ●

● ● ● O ● O O O ● O ● ● O ● ● O O ● O O

O O ● O ● O ● ● ● O O ● O O O ● ● ● O ●

● ● O ● O O O ● ● O O ● ● O ● O ● ● O O

O ● O O ● O ● ● O ● O O ● ● O O O ● ● ●

● O ● O O ● O ● ● O O ● O ● O ● ● ● O O

O O ● O ● O ● ● ● O O ● O O ● O O ● ● ●

● ● ● O O O ● O O ● ● ● O ● O ● O O O ●

● ● O ● O ● O O ● O ● O O ● O O O ● ● ●

● O O ● ● O ● O ● O ● ● O ● O ● ● O O O

● O O O ● ● O ● O ● O ● O O O ● ● O ● ●

O ● ● O O ● ● O O ● O ● ● ● O ● O ● O O

O O ● O O ● ● ● O ● ● O ● O ● O ● O ● O

● O ● O ● O O ● O ● ● ● O ● ● O O O ● O

● ● ● O O O ● O ● O O ● O ● O ● O ● ● O

● ● ● O O ● O O O ● ● O ● O ● O ● O ● O

O ● ● ● O O O ● ● O ● O O ● ● O O ● O ●

O O ● ● ● O ● O ● O ● ● ● O O ● O O O ●

● ● O O ● O ● O O ● O ● O ● O ● O ● O ●

● ● ● O O O ● O O ● ● ● O ● O ● O O O ●

APPENDIX A (cont'd)

28-ELEMENT PATTERNS USED IN EXPERIMENTS I, III, IV

● ○ ● ○ ○ ● ● ○ ● ● ○ ○ ● ○ ● ○ ● ● ○ ○ ● ○ ○ ● ● ○ ● ○

● ○ ○ ● ● ○ ● ○ ● ● ○ ○ ● ○ ● ○ ● ● ○ ○ ● ○ ● ○ ○ ● ● ○

● ○ ● ● ○ ○ ● ○ ○ ● ○ ● ○ ● ○ ● ○ ● ○ ● ● ○ ● ● ○ ○ ● ○

○ ● ○ ○ ● ● ○ ● ● ○ ○ ● ○ ● ○ ● ○ ● ● ○ ○ ● ○ ○ ● ● ○ ●

○ ● ○ ● ● ○ ● ○ ● ○ ● ○ ○ ● ○ ● ● ○ ● ○ ● ○ ● ○ ○ ● ○ ●

○ ○ ● ● ○ ● ● ○ ○ ● ○ ● ● ○ ● ○ ○ ● ○ ● ● ○ ○ ● ○ ○ ● ●

● ○ ● ○ ● ● ● ○ ○ ○ ● ○ ○ ● ○ ● ● ○ ● ● ● ○ ○ ○ ● ○ ● ○

○ ● ○ ○ ● ○ ● ● ○ ○ ● ● ○ ● ○ ● ○ ○ ● ● ○ ○ ● ○ ● ● ○ ●

○ ● ○ ○ ○ ● ○ ● ● ○ ○ ● ● ● ○ ○ ○ ● ● ○ ○ ● ○ ● ● ● ○ ●

○ ● ● ○ ○ ● ○ ○ ○ ● ● ○ ● ● ○ ○ ● ○ ○ ● ● ● ○ ● ● ○ ○ ●

○ ● ● ○ ● ○ ○ ● ● ○ ● ● ○ ○ ● ● ○ ○ ● ○ ○ ● ● ○ ● ○ ○ ●

● ○ ○ ● ○ ● ○ ● ○ ● ● ○ ● ○ ● ○ ● ○ ○ ● ○ ● ○ ● ○ ● ● ○

● ● ○ ● ● ○ ○ ○ ● ○ ○ ● ● ○ ● ○ ○ ● ● ○ ● ● ● ○ ○ ● ○ ○

● ● ● ○ ○ ● ● ○ ● ○ ○ ○ ● ○ ● ○ ○ ● ● ○ ● ● ● ○ ○ ● ○ ○

○ ● ○ ○ ● ● ○ ● ○ ● ● ○ ○ ● ○ ● ● ○ ○ ● ○ ● ○ ○ ● ● ○ ●

○ ○ ● ● ○ ● ○ ● ○ ● ● ○ ● ○ ● ○ ● ○ ○ ● ○ ● ○ ● ○ ○ ● ●

○ ● ○ ● ● ○ ● ○ ● ○ ● ● ○ ○ ● ● ○ ○ ● ○ ● ○ ● ○ ○ ● ○ ●

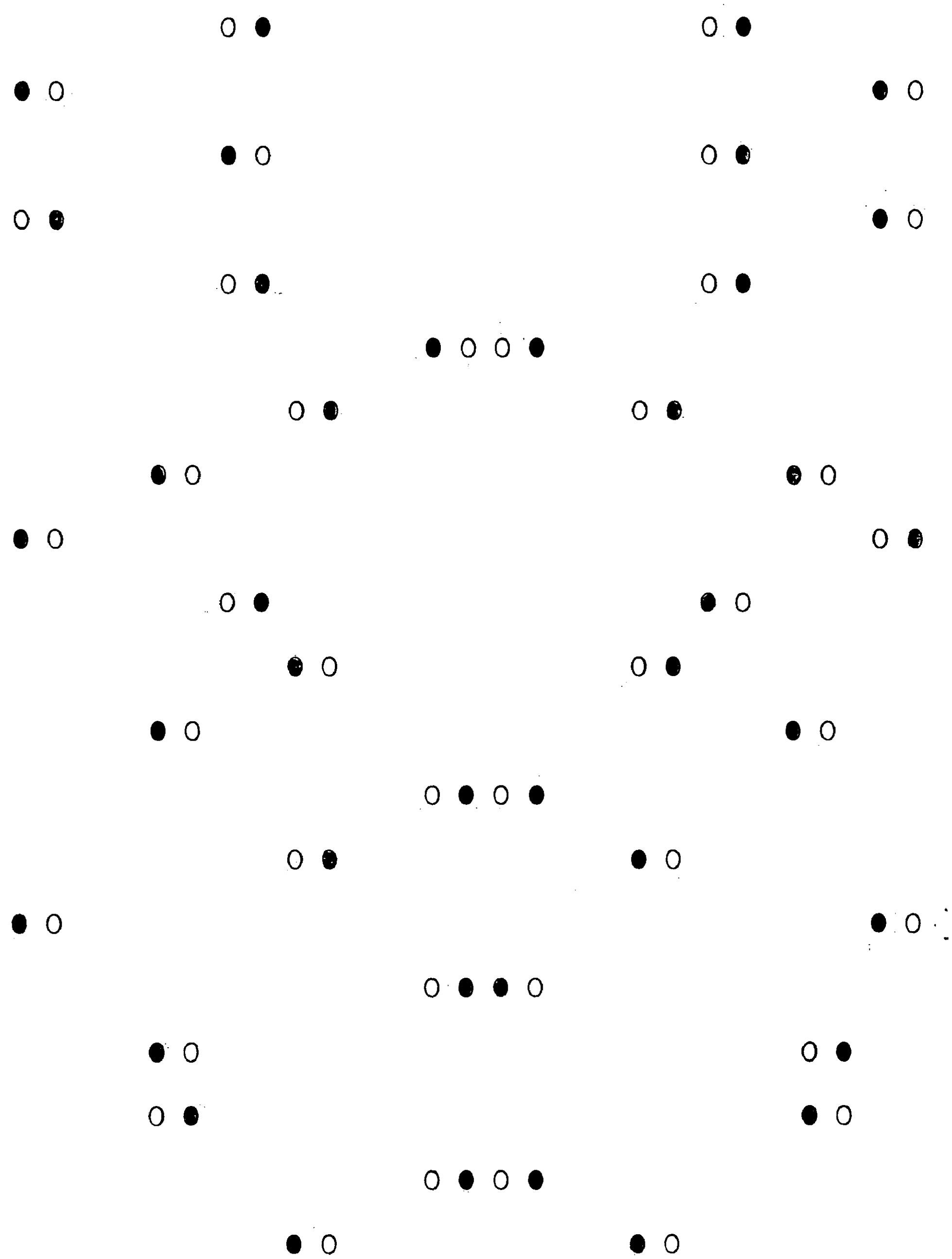
● ○ ● ○ ● ○ ○ ● ○ ○ ● ● ○ ● ○ ● ○ ○ ● ● ○ ● ● ○ ● ○ ● ○

● ○ ○ ● ○ ○ ○ ● ● ● ○ ● ○ ● ○ ● ○ ● ○ ○ ○ ● ● ● ○ ● ● ○

● ○ ● ● ○ ○ ● ● ○ ● ○ ○ ● ○ ● ○ ● ● ○ ● ○ ○ ● ● ○ ○ ● ○

APPENDIX A (cont'd)

4-ELEMENT PATTERNS USED IN EXPERIMENT II



APPENDIX B

INSTRUCTIONS TO SUBJECT

This is an experiment to investigate your perception of visual patterns which will be flashed in the apparatus before you. At the same time the visual pattern is flashed, your eye movements will be recorded. I am interested in how accurately you can reproduce these visual patterns when your eyes are fixed on a point at the center of the visual field. I am also interested in whether you can in fact keep your eyes fixed on the center of the pattern during the entire period of the perception, i. e., just before and during the pattern exposure. The recording of the position of the eyes is necessary because you may not know if you have moved them.

It is essential to the success of this experiment that you try at all times while we are recording to keep your eyes pointed at the cross which appears in the center of the visual field before you. The position of the cross is located so that your eyes will then be pointed at the exact center of the target pattern when it appears.

I will help you adjust the position of your head and eyes so that we can accurately record whether or not you are looking at the cross. When I say, "Ready," maintain exactly that position of head and eyes, and when you are fixating and ready, the stimulus will be flashed. Remain fixating until the flash. Next, promptly mark on the answer sheet your reproduction of the visual pattern that was just flashed. A different visual pattern will appear on each exposure.

The pattern always consists of ____ circles, ____ on each side of fixation [The number of circles presented in any given experiment and half of this number were inserted in these blanks respectively. However, _S_s in the random condition of Exp. I were told that patterns always consisted of either 4, 12, 16, 20, or 28 circles.], half of which will always be filled in. Different circles will be blackened in different exposures, which will be flashed very briefly in a horizontal plane. After the flash is presented you will find a score sheet before you containing the ____ circles that were presented. Please fill in every circle on your score sheet that you saw filled in when the target was presented. The first ten exposures will be practice trials which will help you to become familiar with your task.

If you have any questions, please ask them at this time.

APPENDIX C

EXPERIMENT I - MEAN RAW DATA - CORRECT RESPONSES - ASCENDING CONDITION

Number of Elements	Subjects	2 Left-End Elements	Center-Left Elements	2 Elements Left of Fix	2 Elements Right of Fix	Center-Right Elements	2 Right-End Elements
12	$\underline{S}_1$	28.00	25.50	25.00	19.50	18.50	18.50
12	$\underline{S}_2$	27.00	25.00	21.50	23.50	24.00	22.50
12	$\underline{S}_3$	29.00	24.50	21.00	24.50	21.50	21.00
16	$\underline{S}_1$	27.50	18.75	19.00	18.00	21.75	20.00
16	$\underline{S}_2$	23.50	19.00	21.00	20.00	19.25	20.50
16	$\underline{S}_3$	25.50	17.50	22.50	19.00	18.50	17.50
20	$\underline{S}_1$	22.00	22.67	19.00	24.00	18.33	20.00
20	$\underline{S}_2$	19.00	19.00	18.00	18.00	20.17	17.00
20	$\underline{S}_3$	17.50	19.67	26.50	21.00	18.67	20.00
28	$\underline{S}_1$	20.50	21.70	16.50	21.00	19.70	21.50
28	$\underline{S}_2$	24.00	22.40	20.00	21.00	20.10	20.00
28	$\underline{S}_3$	21.50	20.40	21.00	28.50	19.80	17.50

APPENDIX D

EXPERIMENT I - MEAN RAW DATA - CORRECT RESPONSES - DESCENDING CONDITION

Number of Elements	Subjects	2 Left-End Elements	Center-Left Elements	2 Elements Left of Fix	2 Elements Right of Fix	Center-Right Elements	2 Right-End Elements
12	$\underline{S}_1$	31.00	22.50	19.00	22.50	24.50	21.00
12	$\underline{S}_2$	26.00	20.00	22.50	20.00	22.00	21.00
12	$\underline{S}_3$	27.50	22.00	24.00	21.00	24.00	24.50
16	$\underline{S}_1$	28.50	18.00	19.50	23.50	20.00	16.50
16	$\underline{S}_2$	28.50	17.25	20.50	19.50	18.75	17.00
16	$\underline{S}_3$	22.00	19.25	19.50	22.50	15.50	21.50
20	$\underline{S}_1$	21.00	19.50	16.00	19.50	20.67	21.00
20	$\underline{S}_2$	21.00	22.17	16.50	24.00	21.00	20.00
20	$\underline{S}_3$	20.00	21.67	25.50	22.50	19.33	18.50
28	$\underline{S}_1$	19.00	19.50	19.00	19.00	20.30	25.00
28	$\underline{S}_2$	25.00	21.00	16.50	20.00	21.30	20.00
28	$\underline{S}_3$	24.50	19.70	19.00	22.00	18.60	19.50

APPENDIX E

EXPERIMENT I - MEAN RAW DATA - CORRECT RESPONSES - RANDOM CONDITION

Number of Elements	Subjects	2 Left-End Elements	Center-Left Elements	2 Elements Left of Fix	2 Elements Right of Fix	Center-Right Elements	2 Right-End Elements
12	$\underline{S}_1$	25.50	24.50	26.00	22.50	22.00	16.50
12	$\underline{S}_2$	30.00	27.50	24.00	24.50	22.00	19.50
12	$\underline{S}_3$	22.00	23.50	22.50	25.50	21.00	27.50
16	$\underline{S}_1$	25.50	20.75	14.00	19.00	20.00	18.50
16	$\underline{S}_2$	21.50	17.25	18.00	20.00	21.00	20.50
16	$\underline{S}_3$	26.00	21.25	18.00	22.00	18.75	17.00
20	$\underline{S}_1$	17.50	19.83	20.50	20.50	21.33	19.00
20	$\underline{S}_2$	25.00	20.00	18.50	22.50	19.00	21.00
20	$\underline{S}_3$	23.50	20.83	24.50	25.50	20.67	23.50
28	$\underline{S}_1$	17.00	22.50	18.50	25.00	20.40	26.50
28	$\underline{S}_2$	19.50	19.00	20.50	22.50	19.70	20.00
28	$\underline{S}_3$	19.50	21.10	23.00	19.50	20.50	22.00

APPENDIX F

EXPERIMENT II - MEAN RAW DATA - CORRECT RESPONSES

Experienced Ss (N=3)

Number of Spaces	Element Position			
	1	2	3	4
4	7.66	7.66	7.30	7.30
12	8.00	8.00	7.66	7.66
16	7.66	7.66	6.33	6.33
20	6.66	6.66	6.33	6.33
28	5.33	4.66	6.00	6.00

Experimentally Naive Ss (N=10)

Number of Spaces	Element Position			
	1	2	3	4
4	7.00	7.00	6.80	6.80
12	7.50	7.50	7.30	7.30
16	6.90	6.90	7.40	7.40
20	6.70	6.70	6.40	6.40
28	5.50	5.50	5.60	5.60

APPENDIX G

EXPERIMENT III - MEAN RAW DATA - CORRECT RESPONSES

Experienced Ss (N=3)

Element Position													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
21.6	20.3	22.7	21.7	20.7	17.3	20.3	19.0	19.0	20.0	21.0	18.6	20.0	20.6
15	16	17	18	19	20	21	22	23	24	25	26	27	28
20.6	21.3	20.6	19.6	20.3	23.0	18.3	20.6	19.3	22.0	21.6	20.6	21.6	19.0

Experimentally Naive Ss (N=10)

Element Position													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
22.1	20.5	21.2	18.5	20.5	18.4	18.5	18.8	18.7	19.5	20.8	20.8	21.9	20.4
15	16	17	18	19	20	21	22	23	24	25	26	27	28
18.7	21.1	20.0	20.9	21.4	22.3	19.9	19.2	19.9	18.8	20.0	20.0	20.1	20.1

APPENDIX H

EXPERIMENT III - MEAN RAW DATA - ERRORS OF COMMISSION

Experienced Ss (N=3)

Element Position													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
6.0	15.6	8.0	9.0	9.6	10.3	9.3	10.3	11.0	11.3	8.6	10.3	10.3	6.0
15	16	17	18	19	20	21	22	23	24	25	26	27	28
6.3	5.6	10.3	11.6	10.6	8.0	10.6	10.0	11.0	8.6	10.3	9.6	12.0	10.0

Experimentally Naive Ss (N=10)

Element Position													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
6.6	10.0	10.1	10.5	11.2	10.8	11.3	11.4	10.8	10.6	10.3	10.8	6.2	2.1
15	16	17	18	19	20	21	22	23	24	25	26	27	27
3.4	8.6	10.8	9.7	10.4	8.7	10.3	9.6	9.8	11.5	8.7	10.0	10.4	8.1

APPENDIX I

EXPERIMENTS IV AND V - MEAN RAW DATA - CORRECT RESPONSES - WITH LARGE FIXATION MARKER

Number of Elements	Subjects	2 Left-End Elements	Center-Left Elements	2 Elements Left of Fix	2 Elements Right of Fix	Center-Right Elements	2 Right-End Elements
12	$\underline{S}_1$	25.50	24.50	26.00	22.50	22.00	16.50
12	$\underline{S}_2$	30.00	27.50	24.00	24.50	22.00	19.50
12	$\underline{S}_3$	22.00	23.50	22.50	25.50	21.00	27.50
28	$\underline{S}_1$	17.00	22.50	18.50	25.00	20.40	26.50
28	$\underline{S}_2$	19.50	19.00	20.50	22.50	19.70	20.00
28	$\underline{S}_3$	19.50	21.10	23.00	19.50	20.50	22.00

APPENDIX J

EXPERIMENTS IV AND V - MEAN RAW DATA - CORRECT RESPONSES - WITH SMALL FIXATION MARKER

Number of Elements	Subjects	2 Left-End Elements	Center-Left Elements	2 Elements Left of Fix	2 Elements Right of Fix	Center-Right Elements	2 Right-End Elements
12	$\underline{S}_1$	27.50	29.00	26.50	22.00	21.50	19.50
12	$\underline{S}_2$	28.00	24.00	25.50	27.50	23.00	20.50
12	$\underline{S}_3$	27.00	24.50	35.00	34.50	22.50	20.50
12	$\underline{S}_4$	25.00	24.50	25.00	21.00	22.00	26.00
12	$\underline{S}_5$	18.50	24.50	23.00	19.00	21.50	25.00
12	$\underline{S}_6$	25.00	26.50	31.50	30.50	24.50	22.00
12	$\underline{S}_7$	23.50	20.00	31.50	30.00	21.00	16.50
12	$\underline{S}_8$	26.00	24.50	25.00	26.00	19.00	31.00
28	$\underline{S}_1$	21.00	20.50	28.50	26.00	18.90	16.50
28	$\underline{S}_2$	20.00	20.90	29.50	27.50	19.30	17.50
28	$\underline{S}_3$	20.00	20.70	36.50	35.50	19.60	20.00
28	$\underline{S}_4$	20.00	19.30	25.50	20.50	18.30	20.50
28	$\underline{S}_5$	20.00	19.50	28.50	27.50	19.80	20.00
28	$\underline{S}_6$	20.00	20.30	33.50	33.00	19.30	20.00
28	$\underline{S}_7$	20.00	20.20	28.00	27.00	19.40	20.00
28	$\underline{S}_8$	20.00	20.00	29.00	26.00	20.00	20.50

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VITA

Peter Michael Monti

Born December 21, 1947, in Providence, Rhode Island, the author graduated from Bishop Hendricken High School, Warwick, Rhode Island in June, 1965. He was a psychology major at Providence College from which institution he received the B. A. in June, 1969. The author entered The College of William and Mary in Virginia in February, 1970, and is presently a candidate for the degree of Master of Arts in psychology.

From February, 1970, to September, 1970, the author held the position of graduate research assistant in psychology at The College of William and Mary. He is presently a graduate teaching assistant in psychology at the College of William and Mary.