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OCULAR DOMINANCE IN VISUAL SCANNING

By

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ABSTRACT

OCULAR DOMINANCE IN VISUAL SCANNING

by Stuart J. Agres

A study to test for differences in scanning behavior due to ocular dominance was conducted utilizing a new method of stimulus presentation. Previous studies on scanning typically used tachistoscopic presentations. In the present study _S_s saw lights presented against a dark background. As suggested by other studies, it was hypothesized that scanning proceeds inward from the periphery. It was anticipated that differences in ocular dominance would produce stronger "extreme-to-center" scanning in either the right or left visual fields depending upon the ocular dominance of _S_.

56 college _S_s, equally divided by both sex and ocular dominance, were tested under 2 conditions (28 _S_s participating in each). In Condition 1 _S_s fixated at the center of the display board; in Condition 2 the fixation point was midway between the display board and _S_. The presentation of 2 bulbs to either the right or the left halves of the display board constituted each experimental trial. In each trial the 2 bulbs were either flashed

simultaneously or there was a delay in onset between the 2 bulbs, this done to assess actual discrimination ability in each visual field.

No significant differences in scanning behavior due to ocular dominance differences were observed in Condition 1. In Condition 2 the more extreme bulb was seen as going on first ($p < .01$) by both right and left-eye dominant Ss. Also in Condition 2 the left field was better discriminated by both groups, on delayed-onset trials ($p < .01$). An explanation of differential attention is suggested for this later result.

Approved J. B. McKinney

Date August 1, 1968

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CHAPTER I

INTRODUCTION

While possibly not the first, Leonardo da Vinci conducted what was probably the most thorough analysis of the differences between monocular and binocular vision (this done prior to 1500).[1] Although he realized that differences did exist between the two ways of seeing, he always seemed to assume that the two eyes were equal in both use and ability.

Some of the earliest reports of differential perceptual ability, due to ocular dominance, are from Porta (1593; cited in Miles, 1929):

> Nature has bestowed on us eyes in pairs, one at the right hand and one at the left, so that if we are to see anything at the right hand we make use of the right eye. . . . Whence we always see with one eye, although we think that both are open and that we see with both.
>
> Between the two eyes let there be placed a partition to divide the one from the other, and let us place a book before the right eye and read. If anyone shows another book to the left eye it will not only not be able to read, but it cannot even see the pages, unless in a moment it withdraws the visual virtue from the right eye and changes it to the left.

---

[1] A comprehensive history of ocular dominance to the 1920's is found in Miles (1929), some of which is cited here as background.

> If anyone places a staff before him and brings it directly opposite some crack that exists in the opposite wall, and notes the place, when he closes his left eye he will not see the staff removed from the opposite crack, the reason being that everyone looks with his right eye as he uses his right hand.

As late as 100 years ago, it was still believed a rarity that some people were left-eye dominant. Donders (1864), as cited in Miles, states: "It certainly is true, that we usually abstract from the one eye more easily than from the other. If anyone causes to be distracted the sight to a remote object, it appears, on subsequent closing of the left eye, almost always, that the right eye has been used."

Shastid (cited in Schoen & Scofield, 1935) suggests that the dominant eye is the one which gives the brain the details of the outside world; is the more acute in relaying the necessary visual information; and that the non-dominant eye comes in only now and again with some accessory information. Javel about 1870 (cited in Schoen & Scofield, 1935) assumed that one eye served as the directing eye for determining the object's position while the other operated only in a supporting capacity:

> Most explanations of binocular vision are accompanied by diagrams which show a triangulation, with the base of an isoceles triangle connecting the two eyes and the apex lying at the fixation point in the midline between them. In reality, the triangulation of binocular vision is nearer that of a right triangle with the right angle at the dominant eye (Schoen & Scofield, 1935).

Schoen & Scofield (1935), found that the non-dominant eye serves a somewhat different function. Without stating any implications, they found that the non-dominant eye moves faster than the dominant eye in attending to new stimuli.

In the early 1900's, studies of dominance began to take on a form which has been prominent until very recently: the study of the relationship between handedness and eye-dominance.

Elsin (1910) reported on 65 left-handed adults. "There were 58 of the 65 patients who had equally good vision in both eyes; but only 20 of these brought the finger in front of the left eye." ("Sighting-past-the finger" method of testing for dominance.) This failure of more than half of the left-handed to demonstrate left-eyedness in this task was believed especially remarkable, for he had previously found all right-handed to be right-eyed (cited in Miles, 1929).

In 1925, Mills published a report on eyedness and handedness, finding:

76.0% right-eyed and right-handed
13.0% left-eyed and right-handed
9.3% left-eyed and left-handed
1.7% right-eyed and left-handed

Recent studies have also found the low correlation between handedness and eyedness (Cole, 1957; Fuller & Thompson, 1960; Kruper, Boyle & Patton, 1966; Merrell, 1957), leading Kruper, Boyle & Patton (1966) to say: "It would seem that eye and hand preference are not mediated by a simple common factor, e.g. a single dominant hemisphere."

Recent perceptual studies which may pertain to eye-dominance, are in actuality, typically, concerned with scanning behavior, utilizing dominance (hemispheric), where helpful, as an explanation. These studies utilized tachistoscopic presentations of words, letters, geometric forms, etc., presenting these stimuli either to the left or to the right of fixation, or to both simultaneously.

The general trend of findings in these tachistoscopic scanning experiments has been that when a single letter is exposed to either the left or right fields successively, it is more easily identified when it appears in the right (Bryden, 1966; Bryden & Rainey, 1963; Heron, 1957). Geometric forms or nonsense figures tend not to show such differences (Bryden & Rainey, 1963; Heron, 1957; Terrace, 1959).

The findings of right field superiority on successively presented stimulus items previously cited, are explained by Heron (1957) as being due to a learned scanning process (due to the left-to-right reading of the English language). Presentation of stimuli to the right are more readily identified than those which are at another time presented to the left when the eyes are fixed at the center point of a visual field because the eyes are already located left of the stimulus, allowing the "normal" left-to-right scanning to operate.

In addition to the left or right field placement, the orientation of the material has alternative significance. Mishkin & Forgays (1953) found that Jewish words were more easily identified by Jewish reading Ss in the left field. Harcum & Finkel (1963), found that mirror-imaged words of English were also better identified in the left; but when normally oriented, these words were better discriminated to the right of fixation.

There have been conflicting reports in further studies. Jewish readers sighting Jewish material are only superior in the left field if Jewish was the first language learned. Further, mirror images of single letters are more easily seen in the right field (when right-handed subjects are used; Bryden, 1966), suggesting to Bryden that: "Hemispheric dominance is more important than directional scanning in determining left-right differences in the recognition of single letter material" (Bryden, 1966).

Bryden's study fails, however, to completely test out this argument, in that no left-handed group was used; nor has it been conclusively shown that handedness predicts hemispheric dominance. Handedness has certainly not been a predictor of eyedness.

The previously cited studies of the left-right perceptual differences all deal with the presentation of materials to either the left or the right fields successively. When stimuli are presented to both fields simultaneously, it has generally been found that the left field is better perceived than the right (Crosland, 1931; Crosland, 1939; Heron, 1957), with this difference being found greater for right-eyed subjects than for left-eyed (Crosland, 1939). Dallenbach (1923) found that stimuli presented to the non-dominant hemisphere were more intense for the right handed.

Harcum and Dyer (1962) proposed that:

> If the visual objects are too numerous or too complex to be perceived in their entirety, the component elements must be attended to in some sequence, starting at some reference point. This may require a scanning of the visual field even when the eyes are fixed. . . . The selection of the beginning reference point in the right or left visual field for the scan may be determined by the perceived clarity of the stimuli. Dallenbach suggested that the distribution of attention may produce such greater clarity for the stimulus in the left visual field for most Os.

A combined study of both of these methods of presentation to the two visual fields (successive and simultaneous), was conducted by Bryden and Rainey (1963). "In the simultaneous presentation condition, all types of material (letters, geometric forms, and outline drawings) were more readily recognized in the left visual field. . . . With successive presentation, a right field superiority . . . was observed."

Early studies of ocular dominance attributed little significance to the role of the non-dominant eye in perception. The non-dominant eye has been asserted to be no more than auxiliary to the dominant--though probably a necessary one, in giving information regarding depth and dimension.

In addition, it was thought that the dominant eye was the first to "see" a stimulus and was better able to maintain fixation on it. In 1935, Schoen & Scofield found that the non-dominant eye moves more quickly in adjusting to new stimuli, though this finding was not put to use in a possible refutiation of other of the many beliefs about the nature of eye-dominance.

The present study was undertaken to assess ocular dominance differences in a simple visual discrimination task. Because the non-dominant eye does move more quickly, it was hoped that differences would occur between right and left eye-dominant individuals when a scanning task (with presentations to either side and across fixation) was used.

A previous experimental task was sought, which would fulfill the requisite demands of this experiment and allow for anticipation of the direction of the results. A study by Mackworth (1965) showed that it appeared that scanning proceeded from the periphery to the center (no right or left field differences noted). The experiment called for an identification of a peripheral stimulus when extraneous stimuli were present, either more external or internal to the required target stimulus. Mackworth found that the more external stimuli significantly increased time necessary for the task, while internally presented extraneous stimuli had much less effect, thereby concluding that scanning may proceed from the periphery to the center.

Since this seemed a possible area for testing discriminational differences due to ocular dominance, it was decided that an experiment to test for this scanning phenomenon, with analysis for ocular dominance differences, would prove worthwhile. If scanning did progress as hypothesized, it was reasoned that a simple discrimination task which involved scanning as an integral part, and did not necessitate memory (even relatively short term memory) would best accomplish the demands presented.

CHAPTER II

METHOD

A scanning task was developed, wherein the subject was to make judgments as to which of two adjacent lights went on first, when these lights were presented peripherally in either the right or the left visual field (oral responses). If scanning progressed as hypothesized, from the periphery to the center, it was expected that the lights most external to the fixation point should be seen as going on first more often than those internally adjacent, when the onset of the two were simultaneous.

Subjects

*S*s were 56 college students enrolled in an elementary course in psychology, partially fulfilling course requirements. Twenty-eight female (14 right-eyed and 14 left-eyed) and 28 male (14-right-eyed and 14 left-eyed) were divided into two experimental groups. Each experimental group contained 28 *S*s; seven right-eyed males, seven right-eyed females, seven left-eyed males and seven left-eyed females.

To assess dominance, each *S* was tested for ocular dominance by the use of three common tests for dominance: (a) sighting through a tube, (b) a cone and (c) through a

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1/2 in. hole in a piece of cardboard. For acceptance each S had to pass all three tests consistently, twice.

Apparatus

Four neon bulbs (GE #NE30) were mounted 1/2 in. behind a 44 by 28 in. neutral gray posterboard sheet. Four holes, 3/8 in. in diameter, through the board at distances of 9-1/2 and 13 in. from either side of the center of the board, and 12 in. from the bottom corresponded exactly to the placement of the bulbs.

Running horizontally from the left extreme hole to the right extreme hole was a painted strip (off-white) approximately 1/8 in. in width. At the center of the board was a short (3/4 in.) vertical line, also 1/8 in. in width.

This display board was curved so that it was approximately 70 in. from the subject at all critical points, thus making the visual angles 7°45' and 10°30' to the "central" and "extreme" bulbs respectively. D.C. current (negative pole to the center of the bulb) of 110 V. was used for illuminating the bulbs, so that only the center target (1/2 in. in diamter) of the bulbs was lit.

The apparatus was designed so that only either the right field bulbs or the left field bulbs could be turned on. It was also designed so that either the center or extreme bulbs could have a delayed onset (42 msec.) or so that they were simultaneous. This could be accomplished either from the experimenter's control box (for the practice trials) or automatically, as to prior programming (for the experimental trials).

Though the bulbs could be delayed in onset, they always terminated simultaneously. Total time on for the initially onsetted bulb (and for both bulbs when simultaneous) was 0.372 sec. This time being found optimal during pilot studies.

Room illumination was kept at a constant low level by bouncing a high intensity light from behind S, off the white ceiling, in the otherwise dark room, thereby illuminating equally all parts of the display board.

No potentially distracting stimuli were noted to be present in the S's field of vision, nor were any ever reported by an S.

A chrome plated music stand base and pole were used during Condition 2. (See Appendix A for pictures of the display board.)

Procedure

S sat at a table with a variable height chin rest, 70 inches from the display board. During all instruction periods, Ss were instructed to keep their eyes closed; this was done to both rest and adapt their eyes to the dim illumination condition of the room. Each trial consisted of the presentation of two adjacent bulbs; either the two bulbs to the right or those to the left of fixation.

CONDITION 1

Ss sat as described above, and were instructed to fixate at the center point of the display board. Ss received further instruction to signify which of the two bulbs they observed as going on first, signifying the one closer to the center of the board as "center," and the adjacent bulb as "extreme." Each S was asked to say "ready" when he was sure he was once again looking at the center point of the board.

Practice consisted of up to 62 trials with lights flashed according to a random, but balanced, schedule. S met criterion when he was able to discriminate correctly any of the seven from 10 consecutive trials (after the first 14). Ss who could not reach this criterion were terminated at the 62nd trial.

Rest periods of 15 seconds were administered after every 14 and 10 trials (i.e., after trials #14, #24, #48, #62) during practice. When S completed practice, he was instructed to close and rest his eyes during which time the remainder of the instructions were read; the experiment was then begun.

Presentations consisted of 44 randomly selected trials, of which 20 were of the same delay as during practice; 10 of these to the right and 10 to the left (5 rt.-center, 5 rt.-extreme, 5 left-center, 5 left-extreme).

Twenty-four simultaneous (no delay) trials constituted the remainder; 12 presented to each side. (See Appendix C for order of presentations.) After trial 30 S received instruction to close and rest his eyes (approximately 30 sec.).

The experimental trials differed in the responses required of S in that he was additionally required to give a rating of the certainty of his observation: ("zero," "one," or "two"; with "zero" signifying a complete guess, and "two" relative certainty.

CONDITION 2

All conditions were similar to those for Condition 1, except that a chrome pole (adjustable for height and left-right placement), was placed midway between the display board and S. The tip of this pole was covered for the top 1-1/2 in. with manila colored, non-reflective tape on which a horizontal black line was drawn (1/2 in. from the top). S aligned this line with the height of the horizontal line of the board, and then centered this pole with the center of the board (sighting with dominant eye only). The line on the pole then coincided with S's view of the fixation point of the board.

Ss received instruction to always fixate at the line on the pole, and after each trial, to tell when they were ready for the next trial; when they were looking at the pole tip. Practice and experimental trials both utilized the pole as the fixation. (See Appendix B, for complete instructions to the subject.)

CHAPTER III

RESULTS

Five scores were obtained for each S to assess any differences between the groups:

1. A score was obtained for each S by counting the number of extreme (+1) responses and center (-1) responses, on trials where the two lights on either side were presented with no-delay in onset.

2. A score obtained by including all trials (delayed and simultaneous in onset).

3. A score obtained by considering the rating given for each trial, multiplying that rating ("0," "1," or "2") by the response (center (-1), or extreme (+1)). On delayed

onset trials, a score of zero was given for a correct response; a score of "2" (times the rating) if the response "extreme" was given to a center-first presentation; a response of "center" was scored as "-2" (times the rating) if the presentation was extreme-first.

Thus a score of "0" would be obtained if the S randomly guessed on the simultaneous and either (1) guessed on the delayed, or (2) was correct on the delayed onset trials.

The higher scores for misnaming on delayed trials was done as it was considered a more significant error (in calling, for example, a presentation, "center," if it were actually extreme, than if the lights were presented simultaneously).

4. An "efficiency" score was obtained, by considering only delayed onset trials. Scores of "2" or "-2" were given for correct or incorrect responses respectively, on delay trials. The scores then multiplied by the rating given to each response.

5. A score obtained as in 3 above, but only on delayed onset trials and regardless of the correctness or incorrectness of the response. Scores then obtained would point to the direction of errors on delay trials.

In the scores obtained by methods 3, 4, and 5, ratings were utilized to both obtain S's degree of certainty regarding his response (which was considered to be of potential importance) and to relieve any possible frustration due to the large number of simultaneous-onset trials; S could not give "same" as a response.

Condition 1

Two hypotheses were tested for originally, in each of the two experimental conditions: (1) that extreme lights would be seen more often than center (when simultaneous) and (2) that there would be differences due to ocular dominance.

A summary of resulting averages for each subgroup in Condition 1, is found in Table 1 (average score over all trials, with ratings). Analysis of variance does not show significance for this measure. There is no trend of extreme seen before center and right-left field differences are not significant. There does however appear to be a trend of a right hand bulb being seen before its adjacent left hand bulb (a general trend of right-to-left movement) in both fields.

Analysis of scores on simultaneous trials only, without ratings, is given in Table 2. Once again, analysis of variance does not show significance. Analysis on simultaneous trials only, with ratings, show this same lack of significance.

As relatively high sample variances were obtained, it was felt that the degree to which S was actually able

TABLE 1

AVERAGE SCORES FOR EACH SUBGROUP IN CONDITION 1, AVERAGED OVER ALL TRIALS.

		Left field	Right field
Males	Left eyed	-5.29	-1.86
	Rt. eyed	-1.86	3.71
Females	Left eyed	-2.29	3.57
	Rt. eyed	-6.00	3.43

TABLE 3

AVERAGE SCORES ON CORRECTNESS OF DELAY-PRESENTATION RESPONSES, CONDITION 1.

		Left field	Right field
Males	Left eyed	25.14	23.14
	Rt. eyed	22.86	26.86
Females	Left eyed	16.57	9.14
	Rt. eyed	25.71	21.43

to discriminate differences when such differences <u>did</u> exist, would be an influencing factor on scores. The scoring outlined in 4 was utilized in this analysis; no significant field or sex or dominance differences were obtained (see Table 3).

TABLE 2

ANALYSIS OF VARIANCE, CONDITION 1, SIMULTANEOUS TRIALS ONLY --NO RATINGS.

	SS	df	MS	f
Eyedness	18.285	1	18.285	
Field	35.571	1	35.571	1.458
Eyedness X Field	0.000	1	0.000	
Error	1268.002	52	24.4	
Totals	1320.858	55		

One further analysis was conducted to see where the errors were, when discriminations were incorrect on the delay-onset trials. Scores for this measure were obtained by multiplying the rating by the response (see Fig. 1). The report of "extreme" more than "center" on these trials (all <u>S</u>'s, both fields) is significant ($p < .01$, sign-test; $p < .05$, Wilcoxon sign-rank test).

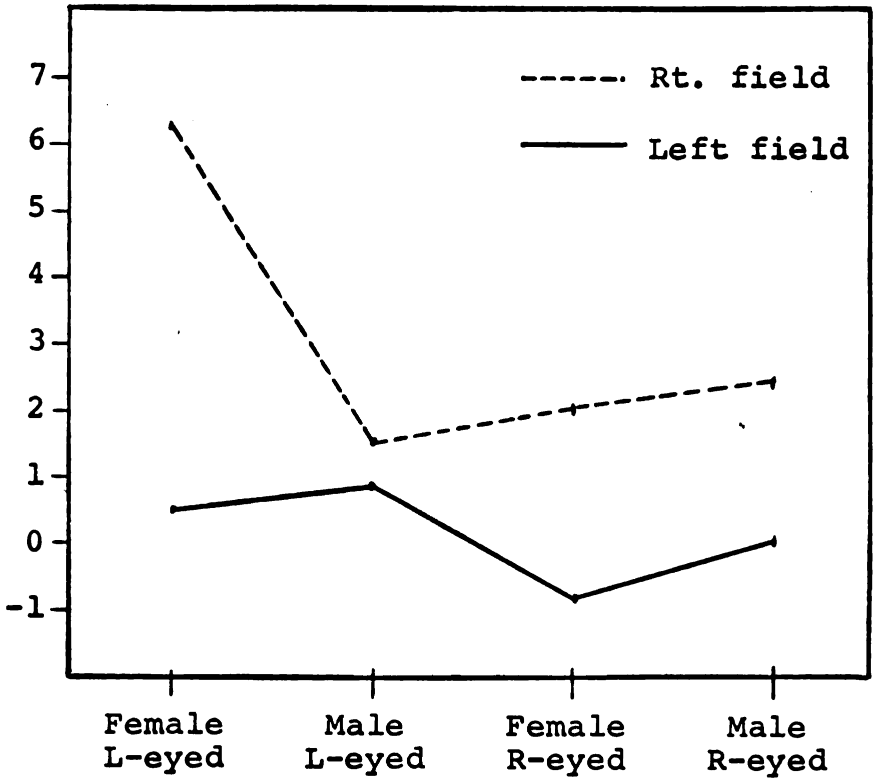

Fig. 1.--The extent to which one response was said more than the other in Condition 1. (A positive score indicates extreme more than center; a negative score, center more than extreme.)

Condition 2

As in Condition 1, analysis of simultaneous trials and overall averages, averages on discrimination ability, and errors in discrimination were conducted and are summarized in Tables 5, 6, 7 and 8 and in Fig. 2.

TABLE 4

ANALYSIS OF VARIANCE, CONDITION 2, SIMULTANEOUS TRIALS ONLY --NO RATINGS.

	SS	df	MS	f
Eyedness	39.446	1	39.446	1.282
Field	189.446	1	189.446	6.159*
Eyedness X Field	75.445	1	75.445	2.453
Error	1599.503	52	30.76	
Totals	1903.840	55		

*$p < .025$.

Analysis of all trials with or without ratings did not reach significance (see Tables 5, 6 and 7). Analysis of simultaneous trials without ratings showed a significant ($p < .025$) right-left field difference, the right field being more extreme-to-center and the left field center-to-extreme (see Table 4).

In analysis for discrimination ability (Table 8) the left field is better discriminated than the right field,

TABLE 5

AVERAGE SCORES FOR EACH SUBGROUP IN CONDITION 2, AVERAGED OVER ALL TRIALS.

		Left field	Right field
Males	Left eyed	-2.28	2.28
	Rt. eyed	1.71	2.85
Females	Left eyed	-4.57	4.28
	Rt. eyed	-2.00	-3.00

TABLE 6

ANALYSIS OF VARIANCE, ALL TRIALS OF CONDITION 2 (SIMULTANEOUS AND NON-SIMULTANEOUS)--NO RATINGS

	SS	df	MS	f
Eyedness	70.875	1	70.875	1.087
Field	236.160	1	236.160	3.456
Eyedness X Field	182.160	1	182.160	2.665
Error	3553.788	52	68.342	
Totals	4042.983	55		

TABLE 7

ANALYSIS OF VARIANCE, ALL TRIALS OF CONDITION 2--NO RATINGS

	SS	df	MS	f
Eyedness	0.017	1	0.017	
Field	161.160	1	161.160	2.131
Eyedness X Field	154.446	1	154.446	2.043
Errors	3950.931	52	75.594	
Totals	4266.554	55		

TABLE 8

AVERAGE SCORES ON CORRECTNESS OF DELAY-PRESENTATION RESPONSES, CONDITION 2

		Left field	Right field
Males	Left eyed	21.71	12.86
	Rt. eyed	19.43	13.71
Females	Left eyed	25.43	18.29
	Rt. eyed	23.71	18.86

when a real difference in onset is presented ($p < .01$, Wilcoxon sign-rank; $p < .01$ sign-test), this difference being somewhat, though not significantly, greater for left eyed Ss.

Analysis for differences between fields, dominance and sex showed no significant results when errors in discrimination are observed (Fig. 2). Within groups, significant reporting of extreme more than center is noted; both male and female left-eyed ($p = .05$, Wilcoxon sign-rank; $p < .025$ sign-test), and male and female right-eyed Ss ($p = .02$, Wilcoxon sign-rank; $p < .01$, sign-test).

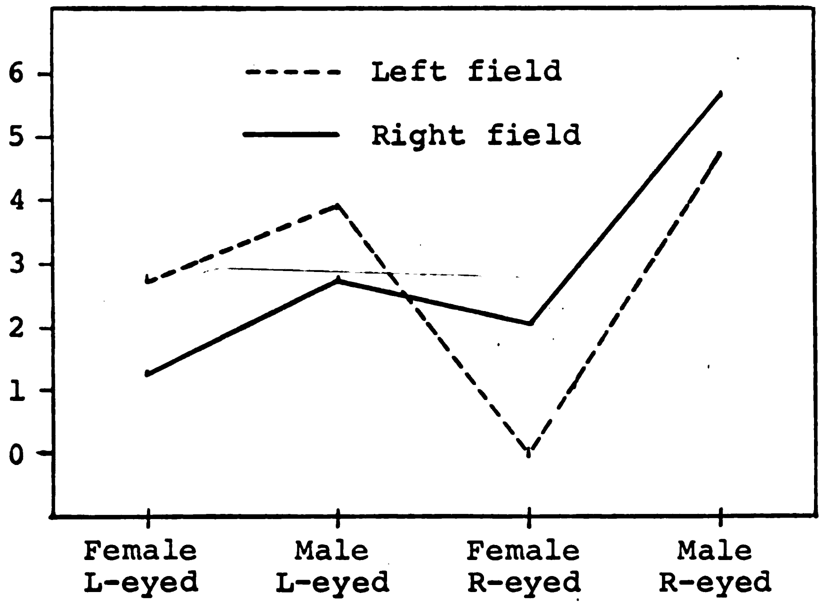

Fig. 2.--The extent to which "extreme" was said more than "center" in Condition 2. (These resulting averages include ratings offered for each response.)

CHAPTER IV

DISCUSSION

In an attempt partially to replicate previous studies, the fixation point in Condition 1 was at the same distance as the stimuli. Condition 2, which utilized a nearer fixation point, was believed to be more closely related to the everyday visual experiences of people. Very often we look at something close at hand and still are aware of objects and especially movement farther away.

It was also believed that presentation of a fixation nearer S would amplify any differences due to both the greater expected attention to the fixation and also because of the slightly greater angle at which the non-dominant eye would be forced to look.

It should be noted here that Condition 1 experiment was conducted prior to that of Condition 2.

It appears that most earlier studies of scanning argue for a learned process, that begins at the left and proceeds to the right (in English reading Ss). The results obtained from these previous studies (e.g., Heron, 1957) are almost invariably that the left field is better discriminated than the right, in experiments where both fields are presented simultaneously. When, however, the stimulus is presented to either the right or the left successively, the right field is better. These results being found for letters and words. When, however, geometric forms, pictures, etc., are used as the stimuli, the results become less extreme or entirely absent.

The current experiment did not show this to be true: the left field was better discriminated than the right--the stimuli were presented successively to either the left or the right fields.

There are two possible explanations for these results. First, it is possible that the horizontal line, which was readily observable during as well as prior to each trial, was more effective in duplicating a full-field presentation than was previously believed. This line was introduced to more closely approximate the study by Harcum and Dyer (1962), and still not necessitate the memory problem inherent in multiple stimuli experiments, for which they have been criticized. Thus, this experiment may have succeeded in causing the phenomenon observed in simultaneous presentation studies (left field superiority).

A second possible explanation, and one which is believed to be more in keeping with several other studies (Dallenbach, 1923 and McKinney, 1967) concerns, in part, the differences between the present experiment and most scanning studies. While this experiment did involve scanning, it was not a replication of any other studies. Other studies utilized tachistoscopic presentations: a dark stimulus against a light background and calling for S to recognize the stimulus from many possible ones, and often to remember this observation long enough to record it. The current experimental situation involved light stimuli against a dark background and the response task was an immediate verbalization of which light was seen first. This being a much different task.

This experiment, in having a light stimulus against a dark background, is similar in many ways to those conducted by Dallenbach and McKinney. Dallenbach projected patches of light into the two fields and McKinney had luminescent lines in the visual fields. Dallenbach's findings, of the left field being more intense, which he believed due to an attentional factor, appears an equally good explanation of McKinney's greater degree of fragmentation of the left visual field. McKinney interpreted this greater fragmentation of the left to be due to a superiority of the right field, which was better able to keep the line in that field from fragmenting as often. It is, however, possible that the greater fragmentation of the left was due to a greater attention to that field (which should cause faster and more frequent fragmentation), this may have predisposed S to identify more readily what happened there. So rather than the right field being superior, the left may be, and because of this superiority have the observed effects.

This explanation makes no reference to hemispheric dominance theories to which both investigators have subscribed, rather it allows for a dominance theory to explain the greater intensity of the left field.

It is therefore possible that the greater discrimination ability shown in this experiment for the left field, may be of the same class as are the observations described above.

The extreme-before-center reports of Condition 2 are as hypothesized, though not on the trials predicted. A possible (Post Hoc) explanation for this "extreme" response observed on non-simultaneous trials and not on simultaneous, may be that the response itself may not have caused this apparent contradiction, but rather the rating given to that response.

It was possible to tell that one light came on before another, and yet not be able to identify which came on first. It is therefore possible that extreme was always seen before center (this was clearly not the case) but that, because the additional cue which signified a relatively long delay between bulbs was absent, lower ratings were given to these responses. It is also possible that a balancing was tried, to compensate for the seeing of "extreme" when a difference in onset times was most evident.

As a partial test for this, it was found that the average rating given an incorrect response on delay trials was significantly higher than those given for simultaneous presentations ($p < .001$, sign test on Condition 2).

It should be noted that the field that was discriminated best also showed the phenomenon of extreme-before-center. It may be argued therefore that this phenomenon is not caused by an inability to discriminate correctly.

One finding, which did not reach significance, is of some interest here: the greater tendency for the contralateral field to the dominant eye, to evidence a greater extreme-before-centerness (see Fig. 2). This finding correlates closely with the findings of Crovitz, Daston, & Zener (1959) who found better recognition of the target in the opposite field of the dominant hand (most significant when same eyedness and handedness).

Because all different methods of presentations in visual scanning (different types of material and modes of presentation) appear to have different results, direct comparisons between studies: this and previous, for example; cannot be made with any degree of certainty. The results of this study, then, should not be construed as being contrary to results found in other experiments. The amount of difference in the methodologies may more than explain the different results obtained.

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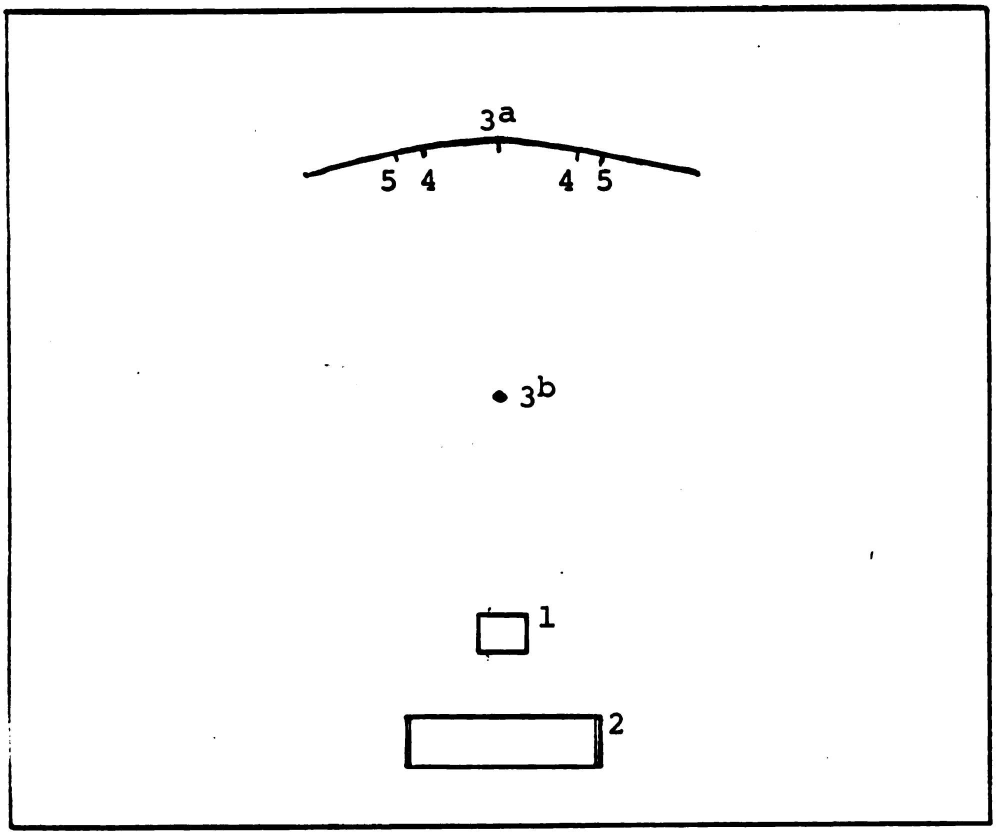
APPENDICES

APPENDIX A



Overhead View of Experimental Room

[1]Subject

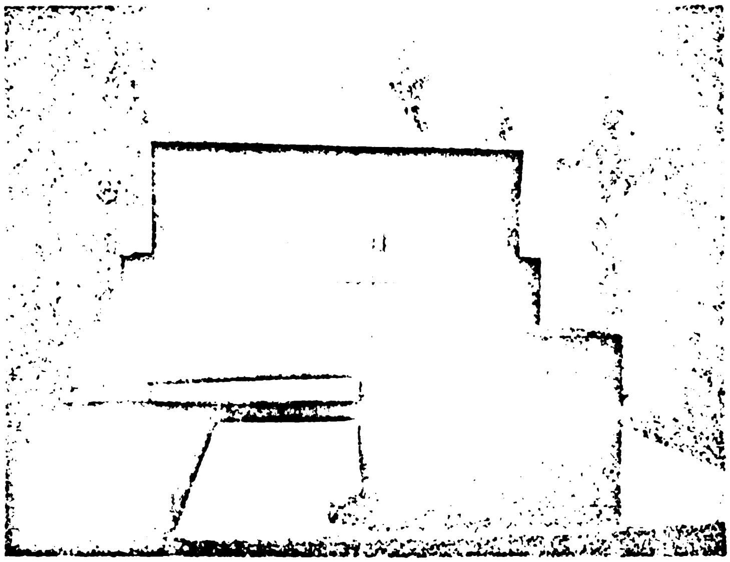
[2]Experimenter

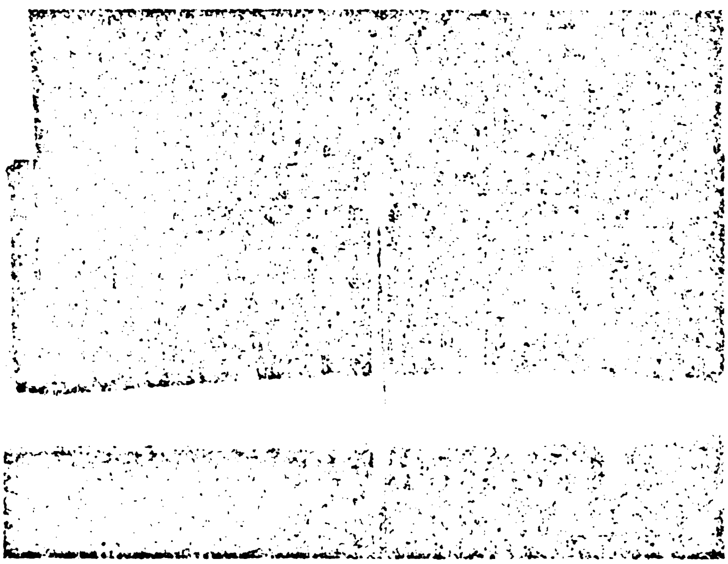
[3a]Fixation (Condition 1)

[3b]Fixation (Condition 2)

[4]Internal lights (7° 45')

[5]External lights (10° 30')





APPENDIX B

DIRECTIONS TO SUBJECTS

This experiment is designed to test a hypothesis about the way people see; it is not in any way a test of your personality or intelligence; but merely an attempt to collect some data from college students, like yourself, about the way they see.

While I am reading these instructions to you, would you please close and rest your eyes.

In this experiment there are two sets of lights mounted on the board in front of you--one set to the left, and the other to the right. Each of these sets contain two bulbs; one, which we will call the "center," is located somewhat closer to the center of the board than the other, and the other we'll call the "extreme."

(CONDITION 1 ONLY) When you open your eyes you will see that there is a line running across the board, and in the center of this line, which is also the center of the board, is a very short vertical line. I want you to always look at this point--where the vertical and horizontal lines cross.

(CONDITION 2 ONLY) When you open your eyes and throughout this experiment, I want you to look at the pole in front of you which we lined up with the center point of the board. Remeber, you are to always look at the line on this pole.

In this experiment one of the following things will happen: either the set of lights to the right, or those to the left will go on, and each time one of these sets goes on, you will see either the "extreme" or the "center" bulb go on first. Remember the extreme bulb is the one farthest from the center of the board. I want you to tell me which bulb went on first: the "center" or the "extreme." You need not tell me which side went on.

Once again this is what I'd like you to do. When the lights Flash, tell me which of the bulbs you saw go on first. They do go on quickly, but each time, I want you to make the best decision that you can and give me your choice, either "center" or "extreme." Since it is sometimes difficult to tell at first, I'll give you some practice trials.

(CONDITION 1 ONLY) Remember you are always to look at the center point of the board--and after each time, would you please tell me when you are sure you are once again looking at the center point.

(CONDITION 2 ONLY) Remember you are to always look at the line on the pole--and after each time, would you please tell me when you are sure you are once again looking directly at the line on the pole.

In summary then, let me repeat what will happen. Each time, either the set of bulbs to the left or those to the right will flash on, one bulb before the other. Immediately after they flash, you tell me which you saw go on first, making the best decision that you can. Your response should always be either "center" or "extreme."

(CONDITION 1 ONLY) Then when you are sure you are looking directly at the point where the two lines cross, say "ready," and then we will be ready for the next trial.

(CONDITION 2 ONLY) Then when you are sure you are looking directly at the line on the pole, say "ready," and then we will be ready for the next trial.

After, and during, the practice session, I"ll ask you to close your eyes again and rest them for a while.

Do you have any questions? (Instructed to open eyes)

Practice session

(Instructed to close eyes)

We are now ready for the experiment itself; and I would like you to do exactly as you have been doing: telling me which bulb went on first. Now, however, during some of the trials, the two bulbs will go on quicker than before, the time between them will be shorter. I still want you to make the best decision that you can, but, this time in addition to telling me either "center" or "extreme," I want you to give me an indication of how sure you are of your choice.

If you are fairly certain, say "2";

If you <u>think</u> you saw it that way, say "1";

If it is a pure guess, and you might just have well said the other, say "zero."

If you are fairly certain, as you probably were at times during practice, say "2";

If you think you saw it that way, say "1";

If it's a pure guess, say "zero."

Once again, give the best decision that you can, not worrying about winding up with more of one response than the other. Tell me which <u>you see</u> go on first, and an indication of how sure you are of what you saw.

Do you have any questions? (Instructed to open eyes)

APPENDIX C

TABLE OF PRESENTATIONS

	Visual Field		Delay		
Trial No.	Right	Left	Center first	No delay	Extreme first
1	X		X		
2	X				X
3	X		X		
4		X		X	
5	X			X	
6		X			X
7	X			X	
8		X		X	
9	X				X
10		X		X	
11		X	X		
12		X			X
13	X			X	
14	X				X
15		X	X		
16		X		X	
17	X				X
18		X		X	
19		X		X	
20		X	X		
21	X			X	
22	X			X	
23	X			X	
24	X		X		
25	X		X		
26	X			X	
27		X		X	
28		X		X	
29	X			X	
30	X		X		
30 sec. rest period					
31		X		X	
32	X				X
33		X			X
34		X		X	
35	X			X	
36		X			X
37		X			X
38	X			X	
39		X	X		
40	X			X	
41		X		X	
42		X	X		
43		X		X	
44	X			X	

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