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A Study of Figural After-Effects in the Inverted-“T”-Illusion

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A STUDY OF FIGURAL AFTER-EFFECTS
IN THE INVERTED-"T"-ILLUSION

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Introduction

The term figural after-effect refers to the spatial displacement of a visual figure induced by the inspection of a prior figure. In the figural after-effect paradigm, an observer fixates on a figure called the inspection figure for some time. Fixation is then shifted to a test figure. Any spatial displacement in the test (second) figure is termed the figural after-effect. Generally, maximal figural after-effects are attained with 60 second inspection followed immediately by short test figure exposure (Hammer, 1949; Graham, 1951; Krauskopf, 1954; Parducci and Brookshire, 1956; Sagara and Oyama, 1957; and Kohler and Wallach, 1944). This study is an attempt to determine the nature of the figural after-effect induced by the inverted-"T"-figure under conditions of maximal displacement.

To account for figural after-effects, two theories in addition to the data of Motokawa, Nakagawa, and Kohata (1956a, 1956b, 1957) have been offered. The first was Kohler and Wallach's (1944) satiation theory. A later statistical theory of figural after-effects was presented by Osgood and Heyer (1952).

The Kohler-Wallach theory proposed macroscopic brain fields in the cortex isomorphic to visual figures. These brain fields were said to be initiated by the ionization of cells about the contour of a figure. Since ionization is a relatively slow process, new figures superimposed upon the contours of a previous figure would be displaced because the previous figure 'satiated' the tissue.

Osgood and Heyer (1952) have proposed an alternate statistical theory of the figural after-effect. The Osgood-Heyer theory is dependent upon the physiological nystagmus of the eye. According to the theory, visual images build up a distribution of excitation in the visual cortex. The figural after-effect is due to differences in excitation distributions resulting from the successive presentations of inspection and test figures.

Motokawa, Nakagawa and Kohata's explanation of the figural after-effect is based on findings of fields of electrostimulation in the retina of the eye. The field is initiated at the margin of a stimulus figure and spreads with decreasing velocity to surrounding cells, leaving a field of retinal induction behind. The apparent form and size of a visual stimulus were found to be a function of the pattern of the field of retinal induction. Fields of retinal induction may erase or distort subsequent fields. The figural after-effect occurs when the inspection-figure field distorts the test-figure field of retinal induction.

Although some writers (Kunnapas, 1958; Summerfield and Miller, 1955) have stated that the figural after-effect and immediate illusions involved different mechanisms, McEwen (1958) states that some immediate illusions may be accounted for by invoking the theories of figural after-effects. Fatzinger (1951) and Boersma (1961) have proposed that the inverted-"T"-illusion may be accounted for by the Kohler-Wallach satiation theory. These writers have proposed that satiation occurs in greater concentrations at the vertices of the inverted "T" figure. This satiation forces the viewer to attribute greater length to the vertical line than the horizontal line. Motokawa, Nakagawa and Kohata (1956b) showed a higher measure of retinal induction in the vertices of the inverted "T" figure. These writers claimed the same effect for retinal induction that Fatzinger and Boersma have claimed for the 'satiation' theory.

Kunnapas (1955) stated that the inverted-"T"-illusion is dependent upon the dichosection of the horizontal line by the vertical line. Kunnapas noted that the illusion was greatest with bisection of the horizontal with the vertical and least when the lines formed an "L" figure. Boersma (1961) stated that the lesser illusion of the "L" figure may be a product of unequal 'satiation' on either side of the vertical line. Further, that maximal illusion occurs when equal amounts of satiation occur on either side of the vertical line.

Sagara and Oyama (1957) have suggested that the simultaneous presentation of figures results in algebraic summation of displacement. This suggestion seems pertinent to the argument of Fatzinger and Boersma. The combination of horizontal and vertical lines in the inverted "T" figure may be a summation of satiation (or retinal induction) for each of the two lines. The satiation effects then, may summate to provide the inverted "T" illusion. A purpose of this study is to determine whether displacement effects of equal horizontal and vertical lines in the form of an inverted "T" figure will summate when the lines are presented simultaneously.

The testing of the first hypothesis led to further hypotheses, each of which was tested by an investigation. The second and third investigations utilized the results of the first as controls. The hypotheses were as follows:

<u>Hypothesis I</u>: It was hypothesized that displacement effects of equal horizontal and vertical lines in the form of an inverted "T" figure would summate when the lines were presented simultaneously.

<u>Hypothesis II</u>: It was hypothesized that the displacement effects of a vertical line located one-half the distance from a fixation point of a vertical line previously found not to affect displacement would not affect displacement.

<u>Hypothesis III</u>: It was hypothesized that the displacement of an outline square whose center was located 50% farther

into the periphery than one previously found to affect displacement would be displaced by a horizontal line inspection figure.

Hypothesis IV: It was hypothesized that vertical inspection lines would affect a greater percentage of reports of horizontal displacement of an outline test square as a function of the width of the vertical line inspection figure.

GENERAL APPARATUS, MATERIALS, PROCEDURE, AND SUBJECTS USED IN THE INVESTIGATIONS

The same apparatus and procedure was used for the eight groups throughout the four investigations. The groups throughout the four investigations were labeled with consecutive capital letters for ease of comparison and discussion. Two groups of the first investigation were utilized as controls for the second and third investigations. Because of the preceding statements, the general apparatus, materials, procedure and subjects will be discussed here.

Apparatus

The apparatus consisted of an oblong box constructed of white posterboard 14 inches square and 28 inches long. The apparatus was set on a table so that a one inch diameter viewing hole was at the subject's eye level. The opposite end of the apparatus consisted of a five inch by six inch window and a rack mounted outside the apparatus for the presentation of the inspection and test figures. A 7½ watt light bulb illuminated the interior of the apparatus. The light was mounted below the viewing hole and was not directly observable by the subjects. The light was connected to an on-off switch which was controlled by the experimenter.

Materials

Inspection and test figures were drawn in black india ink on white posterboard cards eight inches by twelve inches. All figures were drawn so that the fixation point was in the center of the window in the apparatus.

Procedure

All subjects were tested in the same classroom at the University. Inspection and test periods were timed with a stopwatch.

Subjects were instructed to sit in front of the apparatus as the instructions were read by the experimenter. With the termination of the instructions, questions raised by the subjects were answered. The subjects were then instructed to view the inspection figure monocularly. The choice of eye was left to the subject. The inspection figure was inserted in the rack of the apparatus and the light turned on. The subject viewed the inspection figure for 60 seconds. At the end of the inspection period, the subject was instructed to close his eye and the inspection figure was replaced by the test figure in the apparatus by the experimenter. This required approximately three seconds but never more than five seconds. Subjects were then instructed to view the test figure. The test period was five seconds in length. At the end of the test period the light was turned off and all figures removed from the apparatus.

The subjects were then asked a series of three questions to determine the direction of displacement of the left-hand or affected test figure square. The questions were asked in random order to avoid influencing the subject's responses. One question determined the relative size of the affected square. Many studies (Sagara and Oyama, 1957; McEwen, 1958; Meyer, Suskemune and Meyers, 1960) have reported a fading of the outlines of the test figure. Another question determined the horizontal displacement of the affected square and a third question determined the vertical displacement of the affected square. The instructions and questions are printed in the appendix.

Subjects

All subjects were students regularly enrolled in Psychology Courses at Western Michigan University. Groups of the four investigations were numbered consecutively for ease of comparison and discussion.

THE FIRST INVESTIGATION

It was hypothesized that displacement effects of equal horizontal and vertical lines in the form of an inverted "T" figure would summate when the lines were presented simultaneously.

Groups

Three groups of 15 randomly assigned subjects were used in this investigation. The groups were assigned the letters A, B, and C, corresponding to an inspection figure.

Inspection and Test Figures

The group A inspection figure was a 5 cm. horizontal line 1½ cm. below and beginning 3½ cm. to the left of the fixation point. The group B inspection figure was a 5 cm. vertical line 6 cm. to the left of the fixation point. The bottom of the vertical line was 1½ cm. below a horizontal plane extended by the fixation point. The group C inspection figures on one card.

The test figure for all groups consisted of two outline squares lying horizontally on either side of a fixation point. The squares were 1 cm. square outline figures, the centers of which lay 4½ cm. from the center of the fixation point. Thus, the left square, if superimposed upon the inspection figures, lay 1 cm. above the horizontal line and 1 cm. to the right of the vertical line. All lines in the figures were 2 mm. in width and the fixation point was 3 mm. in diameter. Figure 1 illustrates the inspection and test figures for groups A, B, and C.

Results

The results of the first investigation are presented in Figure 2. Group A (horizontal line) indicated 7% size effects, 7% horizontal displacement, and 67% vertical displacement. These results were expected except for the indicated horizontal displacement. Generally, displacement is away from the inspection figure (Gardner, 1960). Group B (vertical line) indicated no size effects or horizontal displacement, but did indicate 13% vertical displacement. This group was expected to indicate 13% vertical displacement but no vertical displacement. The opposite was found for this group.

Group C (inverted "T" figure) indicated 13% size effects, 13% horizontal displacement, and 67% vertical displacement. The hypothesis cannot be said to have been fully supported due to the non-expected displacements of groups A and B.

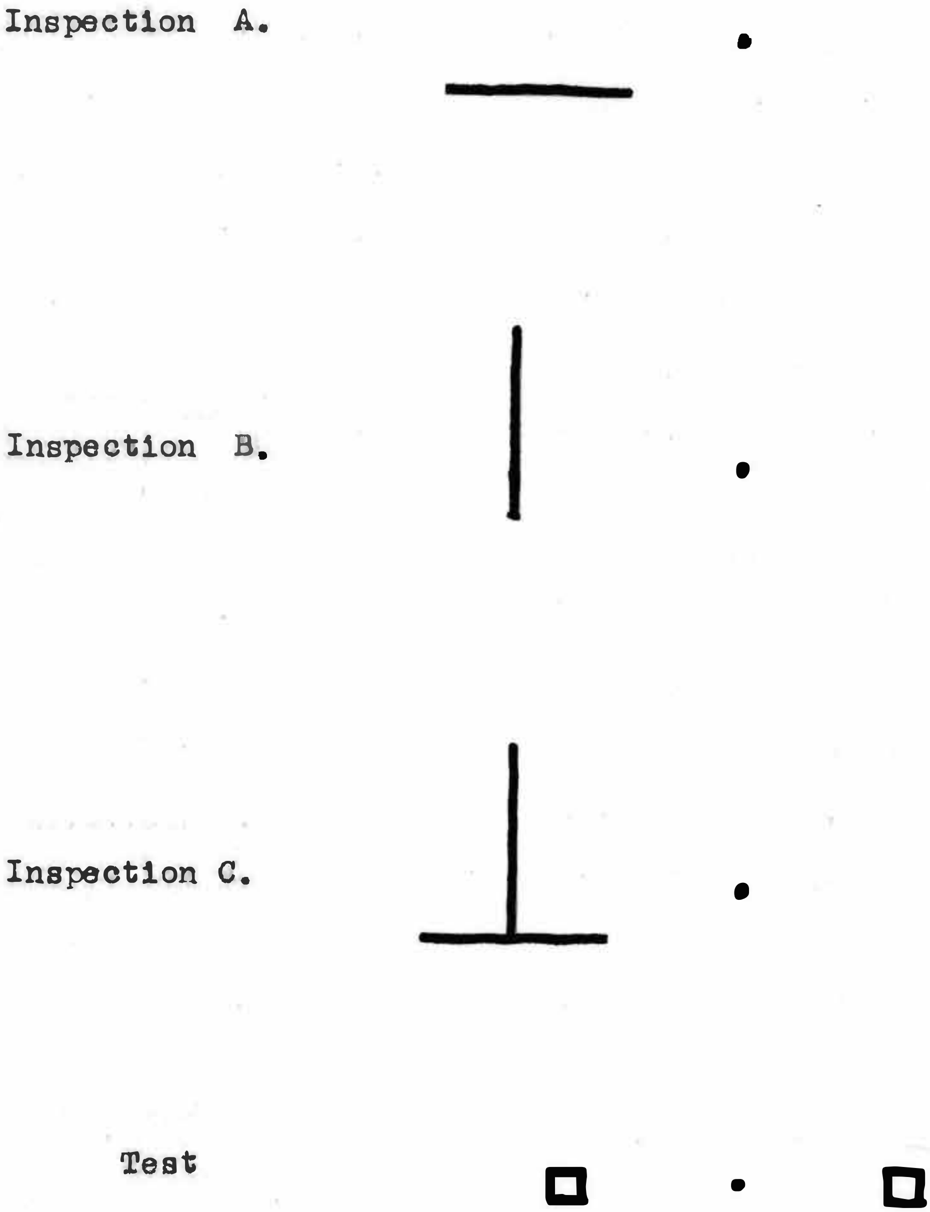

Figure 1. Inspection figures for groups A, B, C, and the test figure for all groups in the first investigation.

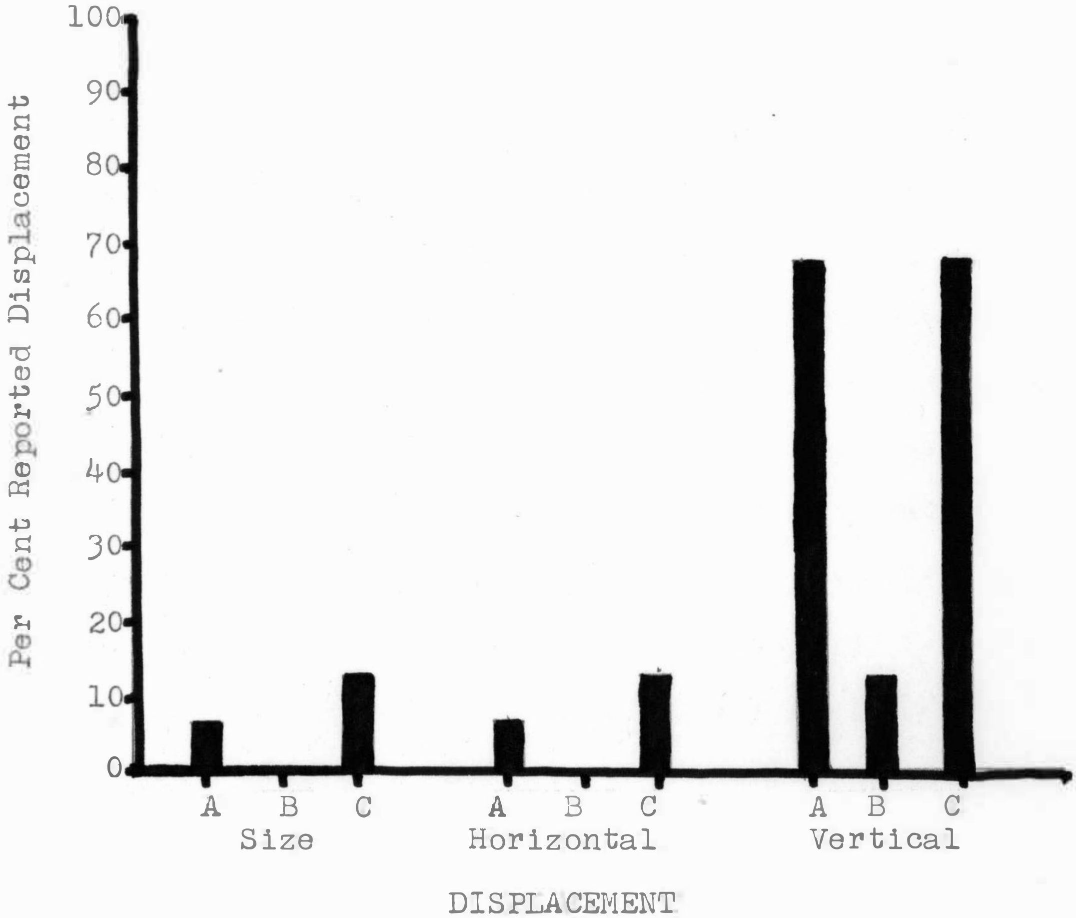

Figure 2. Per cent of reported displacement of one cm. outline test squares from a horizontal line (A), vertical line (B), and inverted-"T"-figure (C).

THE SECOND INVESTIGATION

The results of group B in the first investigation were opposite to those expected. The obtained results may have been due to the difference in distance between the fixation point and inspection figure for groups A and B. Group A was closest to the fixation point and the expected results were obtained in part. The group B inspection figure was at a greater distance and the obtained results were opposite to those expected. The purpose of this study was to determine whether displacements could be obtained if the group B inspection figure were moved towards the fixation point. It was hypothesized that the displacement effects of a vertical line located one-half the distance from a fixation point of a vertical line previously found not to affect displacement would not affect displacement.

Groups

Group B of experiment one was utilized as a control for the performance of group D (N = 10) used in this investigation.

Inspection and Test Figures

The inspection figure for group D was a 5 cm. line located 3 cm. to the left of a 3 mm. diameter fixation point. The bottom of the vertical line was 1½ cm. below a horizontal plane extended by the fixation point. Thus, the inspection figure for group D was the same as for group B of the first investigation except that it was one-half the distance from the fixation point.

The test figure for group D was the same as that for group B. Two outline 1 cm. squares lying horizontally on either side of a fixation point. The centers of the squares were 4½ cm. from the fixation point. Inspection and test figures for groups B and D are illustrated in Figure 3.

Results

The results of the second investigation are presented in Figure 4. The hypothesis was supported since group D performed essentially the same as group B. Group D indicated no size effects, 7% horizontal displacement and 13% vertical displacement. The expected horizontal displacement was obtained but should not be considered significant due to the low percentage (7%). Again, a vertical line inspection figure indicated some vertical displacement which was not expected.

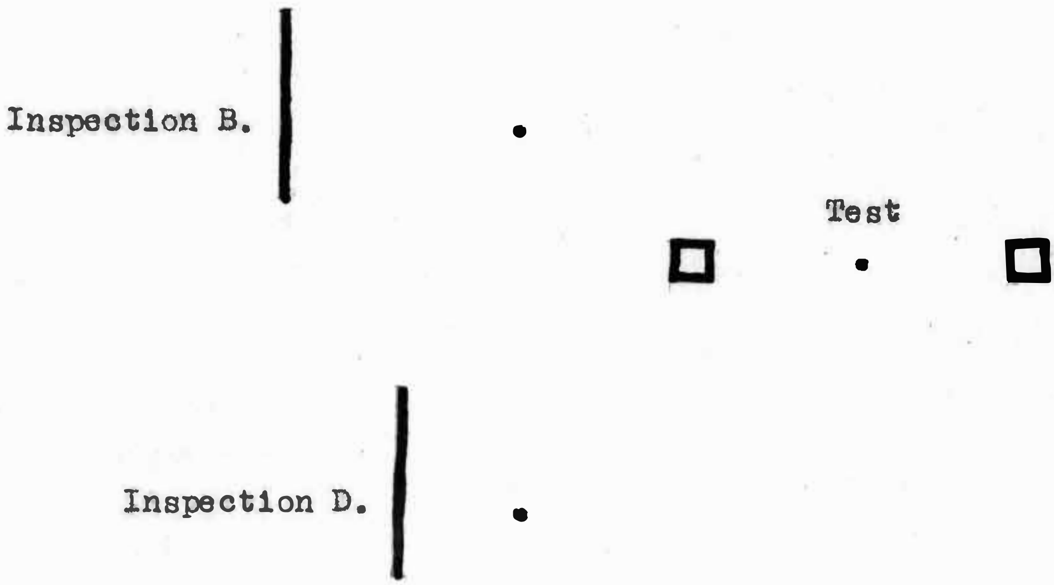

Figure 3. Inspection figures for groups B and D and the test figure for both groups.

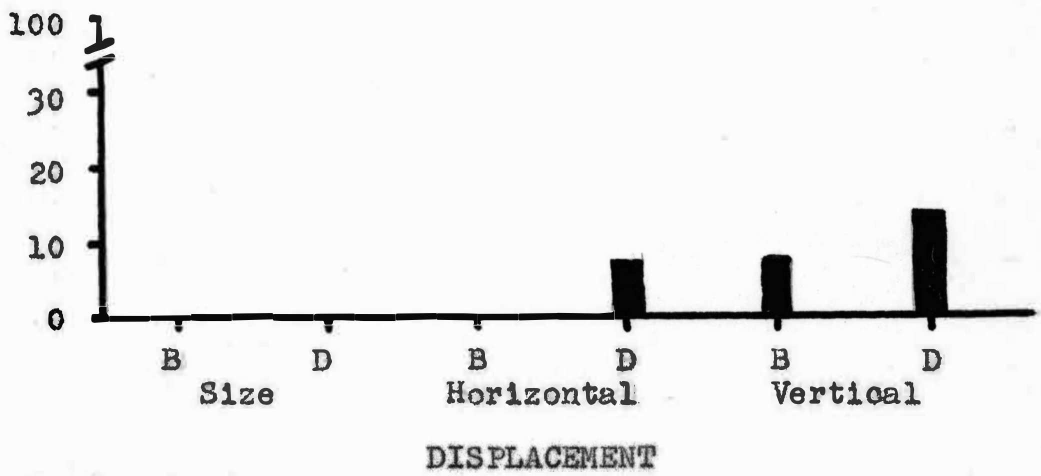

Figure 4. Per cent of reported displacement of one cm. outline test square from 5 cm. vertical lines. Line D was one-half the distance of control (B) from the fixation point.

THE THIRD INVESTIGATION

Meyer, Suskemune, and Meyers (1961) found a greater magnitude of displacement as the visual are (horizontal width) subtended by the inspection figure increased. Likewise, in the second investigation, expected displacement did not change appreciable with reduction of the horizontal width of the inspection figure. The purpose of this study was to determine whether greater horizontal width of the test figure would affect displacement. It was hypothesized that the percentage of reports of displacement of an outline square whose center was located 50% farther into the periphery than one previously found to affect displacement would be displaced by a horizontal line inspection figure.

Groups

Group A of the first investigation was used as a control for the performance of group E (N = 15) used in this investigation.

Inspection and Test Figures

The inspection figure was the same as that used for group A. The inspection figure for group E was a 5 cm.

horizontal line 1½ cm. below and beginning 3½ cm. to the left of a fixation point.

The test figure for group E was essentially the same as that used for group A except that the centers of the squares were 7½ cm. from the fixation point. Thus, the distance from the fixation point was increased 50% for group E when compared to group A. The inspection and test figures for groups A and E are shown in Figure 5.

Results

The results of the third investigation are presented in Figure 6. The hypothesis was supported since displacement was nearly identical for the two groups. Group E indicated 8% more vertical displacement than the control group A. However, there was no change in the per cent of reported displacement for size effects and horizontal displacement.

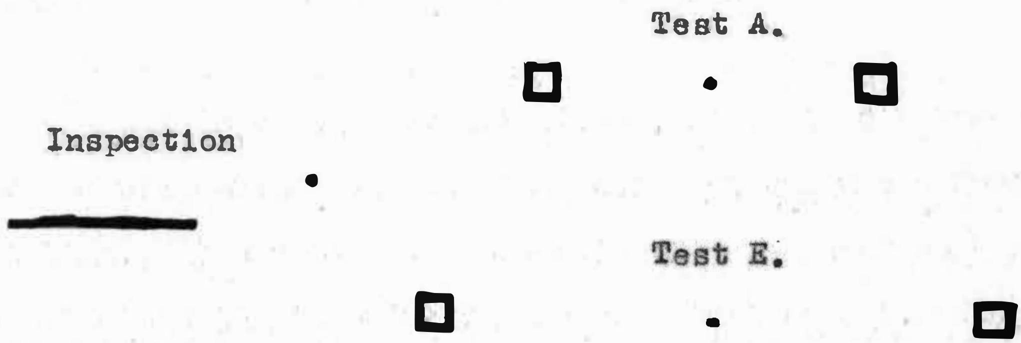

Figure 5. The inspection figure and test figures for groups A and E.

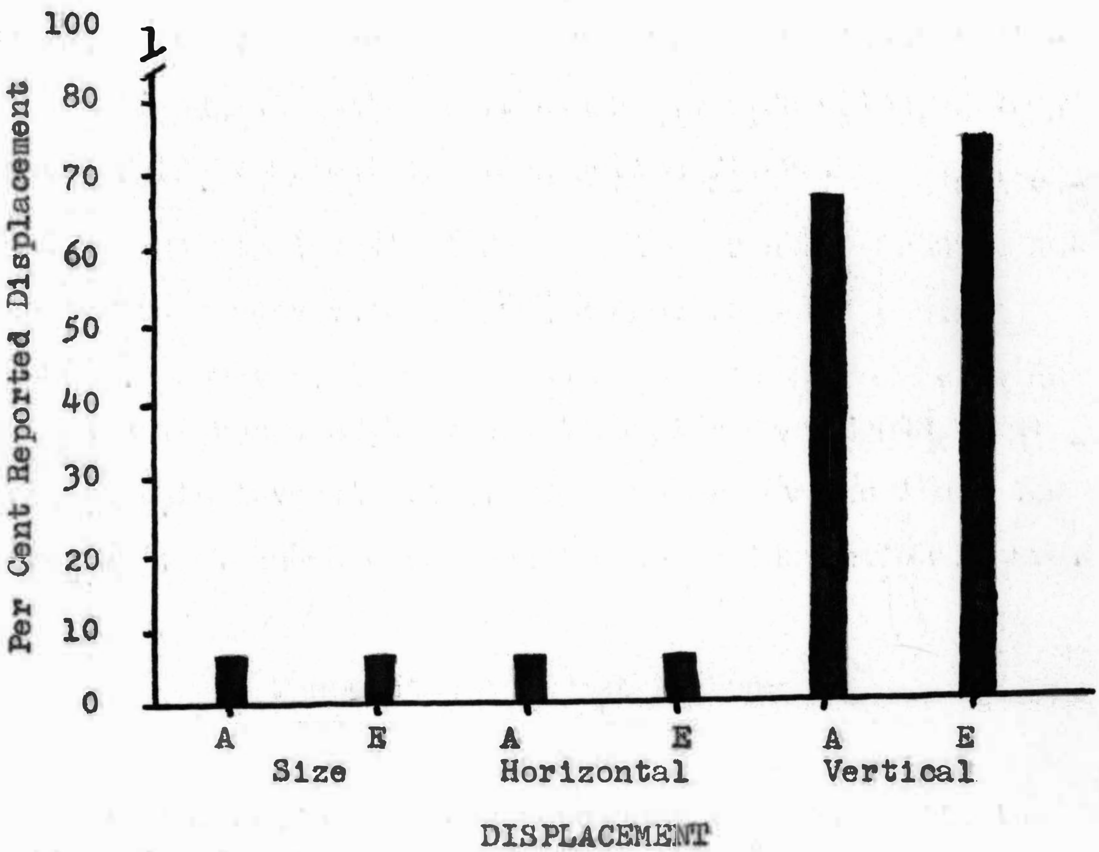

Figure 6. Per cent of reported displacement of one cm. outlint test square from horizontal inspection line. Test figure E was 50% farther into periphery than control group test figure (A).

THE FOURTH INVESTIGATION

In the preceding investigations, sizeable displacements have been reported when the inspection figure was a horizontal line. It may be that inspection figures need some horizontal dimension in order to produce displacement. The purpose of this study was to determine whether increased horizontal width of a vertical line would affect displacement. It was hypothesized that vertical inspection lines would affect a greater percentage of reports of horizontal displacement of an outline test square as a function of the width of the vertical line inspection figure.

Groups

Three groups of 15 randomly assigned subjects were used in this investigation. The groups were assigned the letters F, G, and H corresponding to an inspection figure.

Inspection and Test Figures

All inspection figures were vertical lines with the nearest edge 5 cm. from the center of the 3 mm. diameter fixation point. The bottoms of the lines were 1½ cm. below a horizontal plane extended by the fixation point.

The group F inspection line width was 4 mm. For group G, 6 mm. and for group H, the width was 8 mm.

The test figure for all groups consisted of two one cm. outline squares as before, lying 3½ cm. on either side of the fixation point. The inspection and test figures used in this investigation are shown in Figure 7.

Results

The results of the fourth investigation are presented in Figure 8. Group F (4 mm. inspection line) reported 7% size effects, 13% horizontal displacement, and 27% vertical displacement. Group G reported 20% size effects, 13% horizontal displacement, and 7% horizontal displacement, and 13% vertical displacement.

No definite trend was evident as was predicted by the hypothesis. Again, it is to be expected that displacement will be away from the inspection figure, in this case, horizontal displacement was expected. However, there was a greater total percentage of vertical (non-expected) than horizontal (espected) displacement.

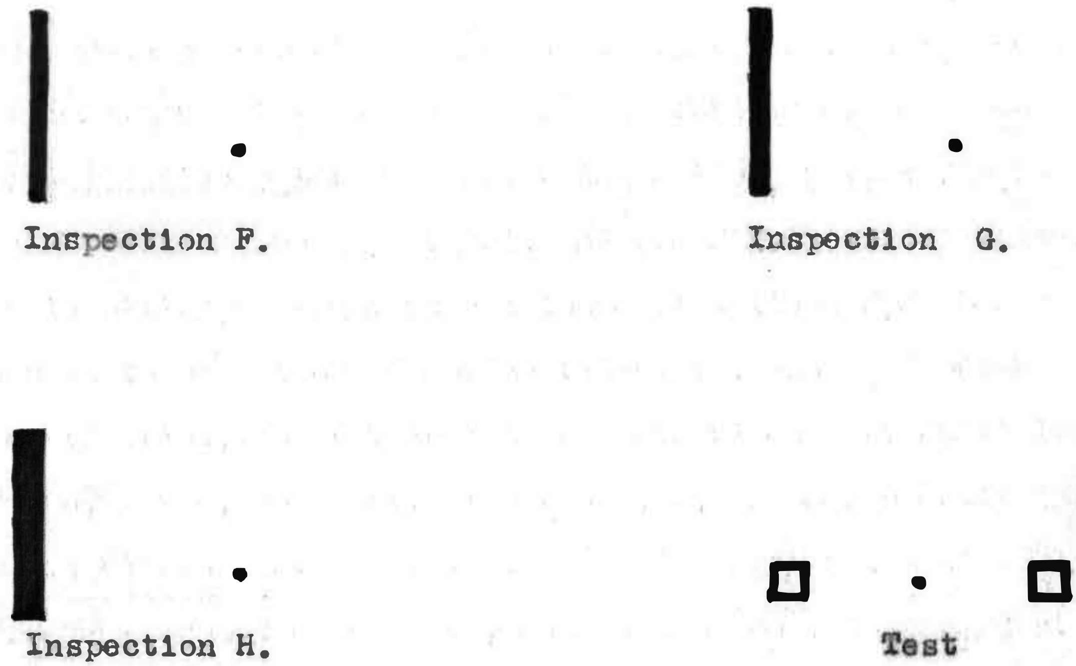

Figure 7. Inspection figures for groups F, G, H, and the test figure for all groups in the fourth investigation.

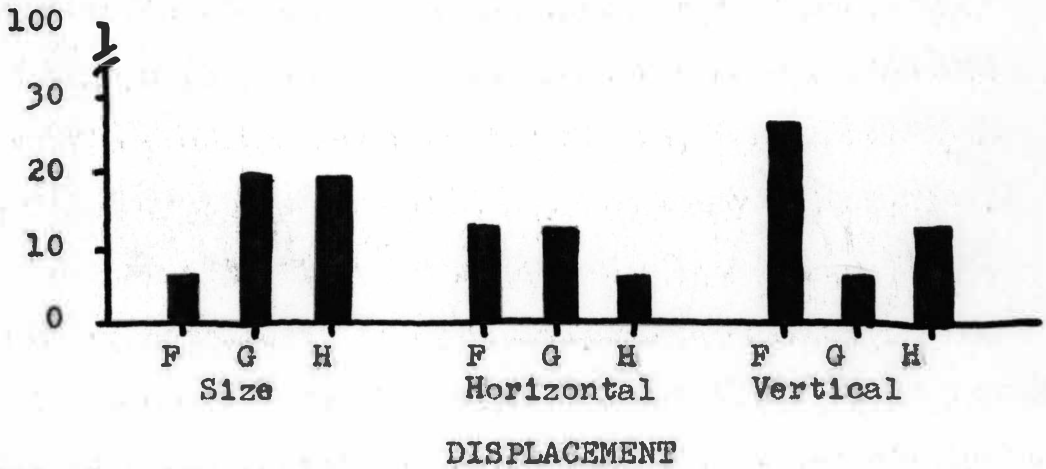

Figure 8. Per cent of reported displacement of one cm. outline test square from vertical inspection lines of varying widths. (F = 4 mm., G = 6 mm., and H = 8 mm.)

DISCUSSION

The results of these investigations indicated that horizontal lines induced sizeable percentages of displacements in the predicted direction. Also, that the vertical lines induced displacement in small amounts and that the direction of displacement was not constant. These findings were not considered an anomaly of the figures used. The distances for maximal displacement were proportional to distances used in other investigations (Kohler and Wallach, 1944; Motokawa, Nakagawa, and Kohata, 1957).

Hammer (1949) utilized short vertical lines as inspection figures. She found that the maximal displacement was only 1' to 2' of visual arc. It may have been that displacement induced by the vertical inspection lines were too small to be detected by the procedure used in the investigations. Further investigations can overcome this difficulty by utilizing an apparatus which allows the subjects to make adjustments of the test figures. In this manner, displacements can be measured directly.

The inability of the vertical line of the first investigation to affect displacement was thought to be an anomaly associated with the distance between the fixation point and the inspection figure. However, the second investigation utilized a shorter distance between the fixation point and inspection figure and the third investigation a greater distance between fixation point and test figures. The results of these investigations indicated that the distances between fixation point and either inspection or test figure did not differ from the results of the first investigation. The inability of the vertical inspection lines was then thought to be a lack of horizontal width. In the fourth investigation, the vertical lines were widened by multiples of two, three, and four. (Groups F, G, and H respectively.) The results of the fourth investigation were not noticeably different from that of the vertical line used in the first investigation.

The results of the four investigations tend to support the contention of Boersma (1961) and Fatzinger (1951). Boersma and Fatzinger state that the inverted-"T"-illusion is induced by 'satiation' of the inverted "T" figure. They state that satiation occurs in greater concentrations in the vertices of the inverted "T" figure, thus forcing the viewer to attribute greater length to the vertical line.

The investigations here, however, tend to show that the respective horizontal and vertical lines of the inverted "T" figure contribute different concentrations of satiation (displacement effects) to provide the inverted-"T"-illusion. The horizontal line induced sizeable vertical displacements, whereas, the vertical lines induced small displacements in both horizontal and vertical directions. These results are

Analogous to the phenomenal impression of the inverted "T" figure. The viewer generally reports a greater length in the vertical line. It may be that the greater vertical displacement induced by the horizontal line is the cause of this impression. Further, that the small satiation effects of the vertical line contribute to this impression.

Sagara and Oyama (1957) stated that simultaneous presentation of inspection figures indicated an algebraic summation of displacement effects. George (1953a) with a procedure similar to that used here, presented two figures simultaneously but did not fing a summation of displacement. The inability of the George study and these investigations may have been a result of the procedure utilized. The magnitude of the figural after-effect tends to be an individual phenomenon (Motokawa, Nakagawa, and Kohata, 1957). Several studies indicating positive results have utilized single subjects or small groups of subjects which were tested extensively (Motokawa, Nakagawa, and Kohata, 1956a, 1956b, 1957, Sagara and Oyama, 1957; Meyer, Suskemune, and Meyers, 1961). The testing of one or a few subjects under the three conditions of the first investigation may tend to show the summation effects indicated by Sagara and Oyama (1957). Another source for the lack of summation effects could be ascribed to the apparatus used in these investigations. An apparatus which allows direct measurement of displacement effects may tend to show a summation of displacement.

The satiation theory has been found to adequately predict the figural after-effect (McEwen, 1958; Osgood and Heyer, 1952). However, the mechanisms underlying this theory have been questioned. Smith (1948) stated that this theory does not adequately account for visual phenomena other than the figural after-effect. Lashley, Chow and Seemes (1951) have shown that macroscopic brain fields do not influence perception. Also, the proposition of a new, non-neural theory has been questioned by Osgood and Heyer (1952) and George (1953b).

The Osgood-Heyer (1952) statistical theory of the figural after-effect has also been questioned. Hockberg and Hay, (1956) Motokawa, Nakagawa and Kohata (1957), and Krauskopf (1960) have shown that figural after-effects can be obtained when the physiological nystagmus of the eye was eliminated. Deutsch (1956) has shown that the difference in excitation distributions are actually too small to be seen. Thus, it seems that while these theories adequately predict the figural after-effect, the mechanisms postulated by these theories are to be considered doubtful.

Motokawa, Nakagawa and Kohata's (1957) more recent findings of fields of electrostimulation have not yet been seriously questioned. Unlike the Kohler-Wallach and Osgood-Heyer theories, this theory offers empirical data to support its claims. Motokawa, Nakagawa and Kohata (1957) have stated that the theories of Kohler-Wallach and Osgood-Heyer were based on inadequate neurophysiological information. Further, that the information now available indicates that the figural after-effect and other illusions are a retinal rather than a cortical phenomena.

For a more adequate investigation of the inverted-"T"-illusion, the methods of Motokawa, Nakagawa and Kohata (1956a, 1956b, 1957) should be applied. These writers have stated (1956a) that the pattern of the field of retinal induction cannot be inferred from the shape of the stimulus figure. It may be that the combination of horizontal and vertical lines into the inverted "T" figure may instigate a field of retinal induction unlike either of the two independent lines. This, then, could account for the lack of findings of algebraic summation of displacement for the lines used in this study.

The results of the investigations presented here indicate that figural after-effects induced by the horizontal and vertical lines of the inverted "T" figure do not summate to provide the inverted-"T"-illusion. The results of the investigations did, however, suggest that the respective lines of the inverted "T" figure provide different amounts of 'satiation' or retinal induction to provide the inverted-"T"-illusion. Horizontal lines in the investigations provided consistent sizeable percentages of reports of vertical displacement. Whereas, the vertical lines, even when widened, induced small percentages of displacement in both horizontal and vertical directions. The results of these investigations are to be considered tentative until more adequate procedures uncover the mechanisms underlying the inverted-"T"-illusion.

SUMMARY

This study was an attempt to determine the nature of the figural after-effect induced by the horizontal and vertical lines of the inverted-"T"-illusion under conditions of maximal displacement. In four investigations, 115 subjects were randomly assigned to eight groups. The same apparatus and procedure was used for each group. The groups differed only in inspection or test figures.

The results of the investigations indicated that figural after-effects induced by the horizontal and vertical lines of the inverted "T" figure do not summate to provide the inverted-"T"-illusion. Horizontal lines in the investigations provided consistent sizeable percentages of reports of vertical displacement. Whereas, the vertical lines, even when widened, induced small percentages of displacement in both horizontal and vertical directions.

It was suggested that the greater vertical displacement induced by the horizontal line caused the inverted-"T"-illusion. Further, that the small satiation effects of the vertical line contributed to the illusion. The results of these investigations are to be considered tentative until more adequate procedures uncover the mechanisms underlying the inverted-"T"-illusion.

APPENDIX

General Instructions to the Subjects

"Psychologists know quite a bit about the center of vision, but very little about vision surrounding the center. In a moment, you will look into this apparatus with one eye at cards that I will insert in here. These cards have a small dot in the center. You are to look at the small dot at all times but notice any other figures. Remember, we are studying vision around the center, so it is very important that you look at the dot at all times."

"You will look at one card for 60 seconds. Then I will ask you to close your eye. While your eye is closed, I will change the card. This takes but a few seconds, so do not move your head. Then I will ask you to open your eye and look at a new card."

"The second card you will look at has a small dot in the center with a square on either side. You will look at this card for a very short time. You are to look at the dot in the center but notice the relative size and position of the squares <u>and</u> remember what you see so that you can tell me."

"Do you have any questions?"

"Cover one eye and look at the dot."

When 15 seconds had passed, "Remember to look <u>only</u> at the dot in the center."

When 60 seconds had passed, "Close your eye, please."

When the test figure had replaced the inspection figure in the apparatus, "Open your eye and look at the dot."

The following questions were asked in random order.

"Did the squares differ in size?" If the response was 'yes', "Which one?"

"Did one square seem to be closer to the dot than the other?" If the response was 'yes', "Which one?"

"Did one square seem to be higher than the other?" If the response was 'yes', "Which one?"

"Thank you."

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