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An Investigation of the Visual Processes Involved in the Vertical-Horizontal Illusion

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AN INVESTIGATION OF THE VISUAL PROCESSES INVOLVED IN THE VERTICAL-HORIZONTAL ILLUSION

by

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AN INVESTIGATION OF THE VISUAL PROCESSES INVOLVED IN THE VERTICAL-HORIZONTAL ILLUSION

The vertical-horizontal illusion has been the object of experimental study for many years. The first man to investigate the vertical-horizontal illusion was probably Oppel in 1854. Since the time of Oppel's first experiment, many theories have been advanced in an attempt to explain what causes this illusion to occur in our perception of connected vertical-horizontal lines. The primary theory that is most widely accepted states that the vertical line in the "T" illusion will be judged longer because of the vertical-horizontal relationship.

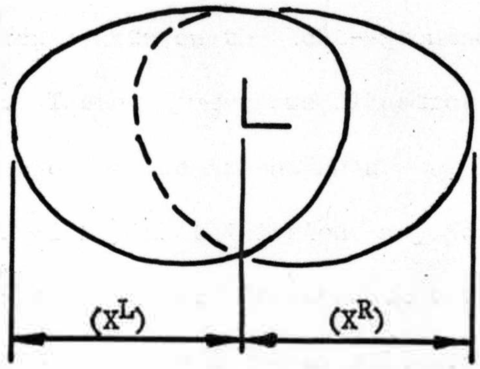
Pan (1934) suggested that the "T" figure illusion was not due entirely to the interaction of the vertical and horizontal line, but rather to the perculiar characteristics of the figure itself. He found less illusion present in vertical-horizontal lines when they did not form the "T" figure. In support of this theory Finger and Spelt (1947) found evidence that the vertical-horizontal illusion present in the inverted "T" figure was the result of the interaction of two separate illusions, i.e., overestimation of the vertical line and overestimation of the dividing line. Fatzinger (1951) stated that the bisected line and the vertical-horizontal position of the lines are only minor contributors to the total "T" illusion. He was able to determine, by rotating the "T" figure, that position of the "T" had little effect on the amount of illusion present. This finding did not support the primary theory of vertical-horizontal line relationships. Rather, he suggests that the total configuration of the "T" is the major determinant of the vertical-horizontal illusion found in that figure.

Kunnapas (1955) supported the finding by Finger and Spelt that the vertical-horizontal illusion was due to the combined effects of the bisected line illusion and the vertical-horizontal line relationship. He also found that illusion due to dichosection is independent of vertical direction. The vertical illusion is always connected with the vertical position whereas illusion due to dichosection is variable. The dichosection illusion has its maximum effect at the midpoint position and its minimum effect at the two end positions. The two illusions operate in the same direction and summate when in the "T" position. The two illusions operate in opposite directions when the "T" figure is rotated on its side and the total effect is equal to the difference between each effect. Kunnapas (1955) states, "At the two end positions or the "L" figure the amount of illusion due to dichosection is equal to zero."

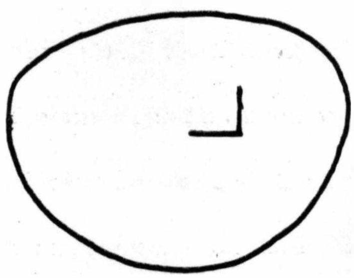
Kunnapas (1957) initiated a new approach when he investigated the vertical-horizontal illusion using the "L" figure in an attempt to find if there was any relationship between the shape of either monocular or binocular visual field and illusion. He found that when the "L" figure is seen by the left eye, extension of the horizontal line to the left produces a larger overestimation of the vertical than when the same line is extended towards the nasal portion of the monocular field of vision. However, in binocular vision where the fixation point is equidistant from both lateral boundaries, he found no significant difference between the left-extended and the right-extended "L" figures. These figures are illustrated in Figure 1.

On the basis of previous research (Kunnapas, 1957) it was suggested by Kunnapas (1958) that illusions may partially be caused by the shape of the visual field. He found that the monocular visual field is not only oval, but also asymmetrical, i.e., the fixation point is nearer the nasal boundary than the temporal. Therefore, when the center of a horizontal line is fixated with the left eye, the right side of the line is nearer to the nasal boundary and appears subjectively longer than the left side of the line. The left side of the line is underestimated and consequently set too long. When eyeglasses were worn that changed monocular fields into round artificial fields, the underestimation of the temporal side of the line decreased. These findings suggested that the vertical-horizontal illusion found in monocular viewing of the "L" figure is due to a peripheral characteristic of the visual system, the shape of the visual field.

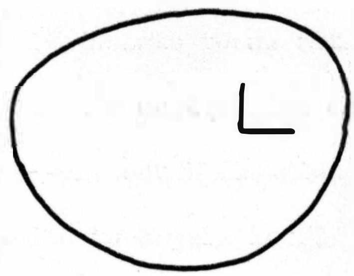
Additional evidence that the vertical-horizontal illusion may be due to peripheral characteristics of vision was presented by Ohwaki (1960). He has investigated geometrical illusions using stereoscopic vision. Stereoscopic vision allows each eye to see only half of the illusory figure. He found that four illusions (Tichener circles, Helmholz squares, Muller-Lyer, and Poggendorf) were due to the pattern of the stimulus presented to each eye simultaneously and disappeared under stereoscopic observation. However, in using the "T" figure the vertical-horizontal illusion appeared the same in stereoscopic



a. Binocular visual field.
(X^L) Equals (X^R)



b. Left-extended figure in the left monocular field. Represents temporally oriented "L" figure.



c. Right-extended figure in the left monocular field. Represents nasally oriented "L" figure.

Fig. 1. Figures used by Kunnapas (1957) to demonstrate the relationship of the "L" figure to the binocular and monocular field of vision.

vision as it did in ordinary vision. He believed this was due to the anisotrophy of space. Ohwaki defined anisotrophy as the phenomena inherent in the particular direction of elements of the figure in space independent of the total configuration. Anisotrophy is defined in the dictionary[1] as a geometrical configuration that exhibits different properties when tested along axes in different directions. From this theoretical viewpoint Ohwaki argued for a directional explanation of vertical-horizontal illusion. He stated that anisotrophy of space is a retinal process. Therefore, if two retinal stimuli are objectively of the same extent, the vertical extent is overestimated to the horizontal extent.

More evidence of the vertical-horizontal illusion as a peripheral process was given in the study of retinal induction fields and figural after-effects by Motakawa (1950). He found a correspondence between the appearance of geometrical illusions and the field of retinal induction produced by geometrical illusions. He found that the process at the peripheral level is not correlated with the physical stimuli in a one to one relationship. He claims that this finding supports a theory of peripheral field and is, therefore, in direct opposition to Kohler's theory of cortical field.

Hammer's (1949) finding that figural after-effect depends on cortical neural processes adds emphasis to a peripheral explanation of illusion when work done by Kunnapas in this area is considered. Kunnapas (1958) states that virtually no figural after-effect occurs

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[1]Webster's New Collegiate Dictionary, 2nd ed. Springfield, Mass: G. C. Merriam Co., 1958.

in the absence of fixation, while observation without fixation favors a significantly larger illusory effect. Kunnapas attributes figural after-effect to a factor which counteracts overestimation, so that the mechanisms underlying the vertical-horizontal illusion and figural after-effects must be presumed to be different.

The experimental procedures used by Fatzinger (1951) served as a model for the design of the experiment presented in this paper. He used the psychophysical method of average error. The subjects were required to adjust the length of a variable line until it appeared to be the same length as the 50 millimeter standard line. No knowledge of results was given to the subjects. The "L" figure and the "T" figure were used to study the vertical-horizontal illusion. The "T" figure illusory effect was studied in several different angular orientations.

The study presented in this paper had two purposes: (1) to find out if the vertical-horizontal illusion is a phenomenon of the peripheral characteristics of vision or of the higher cortical centers of the brain, and (2) to find out if in monocular vision the factors underlying illusion in the inverted "T" are the same as the ones for the "L" figure. It is hoped that this study will partially satisfy the general need of a greater understanding of illusions. Knowledge of the location of the basic visual processes underlying the perception of the vertical-horizontal illusion may help other investigators to determine the cause of this illusion.

This study was based on five assumptions. The first assumption is that if the vertical-horizontal illusion is due to a peripheral characteristic of vision, then interocular differences should be found.

However, if the illusion is due to a cortical characteristic of vision, then no interocular differences should be found, and any gradient of adaptation occurring in one eye should continue when the other eye is exposed to the same monocular field orientation of the figure. The second assumption is that the inverted "T" is a balanced figure and the "L" is an unbalanced figure. Balance was defined as horizontal extension of the base line of each figure in opposite directions the same distance from the point of intersection of the vertical and horizontal lines. The third assumption is that monocular adaptation to the inverted "T" and "L" figure will occur and the amount of illusory effect will decrease over a series of trials. The fourth assumption is that the fixation point of the monocular field of vision is closer to the nasal boundary than it is to the temporal. The last assumption is that subjective length of the vertical line is influenced by the objective length of the horizontal line from either boundary.

This study does not attempt to identify the neurological processes involved in vision and perception, nor does it specifically identify either the higher cortical or the peripheral locations referred to. Peripheral vision is defined here as a process occurring anterior to the optic nerve. Everything posterior to this is defined as higher cortical processes.

This investigation was planned as an attempt to verify the following things. First, the peripheral characteristics of our monocular field of vision as found by Kunnapas (1958) partially determines the amount of illusion that is present in the "L" figure. Second, the inverted "T" and "L" figures are affected differently by these characteristics. The inverted "T" should show the same amount of initial illusion in the adaptation eye and the test eye. This proposition is based on the assumption that the inverted "T" is a balanced figure and bears the same orientation to the fixation point and nasal boundary in either eye and is, therefore, less influenced by these characteristics. The "L" is an unbalanced figure and it is therefore possible for this figure to bear two different orientations to the fixation point and nasal boundary. If the "L" figure presented to both eyes bears the same relationship to the fixation point and nasal boundary, then it will show the same fluctuation as previously stated for the inverted "T" figure. However, if the orientation changes, the illusory effect will either increase or decrease with respect to the amount of initial illusion found in the adapted eye. Therefore, the "T" illusion is determined by its total configuration in the monocular field of vision and the "L" figure illusion is determined by its orientation to the boundary. Third, the inverted "T" and the "L" figure illusory effect is due to peripheral characteristics of vision. Therefore, the illusory level obtained after a period of adaptation in one eye should fluctuate either upward or downward when the other eye is initially tested.

The research presented in this paper was designed to test the following two hypotheses: (1) the illusory effect of the inverted "T" figure present in the first ten trials with the left eye will equal that found in the first ten trials and exceed that found in the last ten trials with the right eye. (2) the illusory effect of the "L" figure present in the first ten trials with the left eye will equal that found in the first ten trials and exceed that found in the last ten trials with the right eye when using the temporally-oriented "L" figure for both eyes, but will be less than the first ten trials with the right eye when using the temporally-oriented "L" figure in the right eye and the nasally-oriented "L" figure in the left eye.

Method

Subjects. Sixty college students from general psychology classes at Western Michigan University were used as subjects. The subjects were randomly divided into two groups of 30 each. Sequential numbers assigned to each subject at the time of scheduling provided the basis for a random division into an odd-numbered and an even-numbered group. Subjects wearing corrective lenses were permitted to participate in the experiment. All subjects were asked if they knew of any serious defect in either of their eyes, as yet uncorrected. Subjects reporting in the affirmative were rejected. The Snellen Eye Chart was used as a final check of the eyes. Each subject was required to cover the right eye and read the bottom line of the chart from right to left, then cover the left eye and read the same line from left to right. Each letter that was not read correctly was counted as an error. A subject was accepted if no errors were made or if the number of errors made during the test of the right eye equaled or varied by not more than one the number of errors made during the test of the left eye. Subjects not meeting this criterion were rejected.

Apparatus. The apparatus used was a 21-inch long, completely enclosed, octagonal box made of 3/8-inch plywood. The box was light-tight; one side was hinged to permit access to the internal structure.

On the front of the box were the eyepiece, through which the subject looked, and the control knob, which permitted the subject to make adjustments to the variable line. The control knob was connected by means of a shaft running lengthwise through the box to a calibrated millimeter dial mounted on the back. This permitted the experimenter to read and record in millimeters the adjustment made to the variable line by the subject. Four control levers mounted on the back were geared to covering masks attached to the inside back wall of the box.

The interior of the box was painted a dull, non-reflecting black. A green plastic filter was placed over the eyepiece inside the box to eliminate all extraneous visual cues. Two electrical light bulb sockets were also mounted on the inside front wall. Each held a two-watt ultra-violet, argon-glow bulb.[2]

On the inside back wall were mounted the gear rack and the externally controlled masks. The gear rack carried two movable masks that either lengthened or shortened the variable line when the control knob was turned. Two stationary metal strips that crossed at right angles were mounted beneath and parallel to the masks. Green fluorescent paper[3] strips 3/64-inch by approximately 3-inches long were glued to each of the four metal strips.

The externally controlled masks could be adjusted to block off certain segments of these fluorescent strips. The masking effect coupled with the proper rotation of the box to any one of the eight

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[2]Purchased from: the Stroblite Company, 75 West 45th Street, New York, New York.

[3]Ibid.

sides permitted the experimenter to obtain the stem and base variable "T" figure and stem and base variable "L" figure in a right and left orientation.

One complete revolution of the control knob resulted in a 150 millimeter change on the base variable "T" figure or a 75 millimeter change on all other figures. Correction for this difference in calibration was made when data were recorded. The standard or comparison line was always 50 millimeters long. The four figures used in this experiment are illustrated in Figure 2.

Procedure. Each subject was seated in front of the apparatus. He was then read a list of instructions by the experimenter (see Appendix A). The room was totally dark except for a dim red light on the back of the apparatus that permitted reading of the dial. There were thirty subjects in each group, one group being presented with the inverted "T" figure and the other group with the "L" figure. Half of the subjects in each group were presented with the stem-variable figure and half with the base-variable. Each subject received 60 trials on the inspection figure with the right eye. The subjects viewing the inverted "T" figure then received 10 trials on the inspection figure using the left eye. The subjects viewing the "L" figure received 60 trials with the horizontal line extending towards the temporal side of the monocular field of vision, 10 trials with the left eye viewing the "L" figure with the horizontal line again extending towards the temporal side, and 10 more trials with the left eye viewing the same figure, but with the horizontal line extending towards the nasal side of the field of vision.

Fig. A

Fig. B

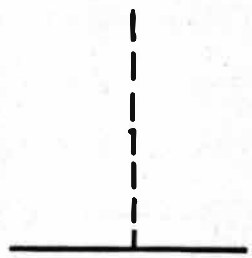
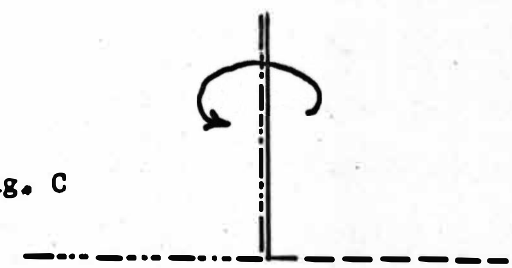
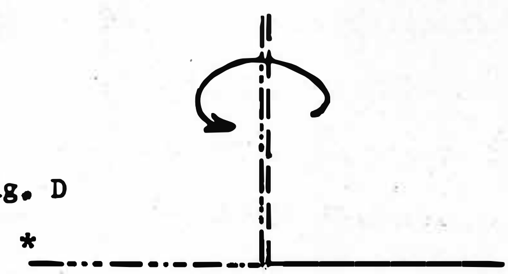


Fig. C



Right orientation Left orientation

Fig. D



Dash line indicates variable line in test figure.
* (—-.--—) represents the "L" figure reversed.

Fig. 2. Figures used in experiment.

The psychophysical method of average error was used which required the subject to make adjustments to match a constant stimulus. The variable line was alternately set too long or too short by the experimenter to avoid "pulling" the subjects' judgment in either direction. The starting lengths of the variable line were also varied. No knowledge of results was given.

The subject viewed the stimulus figure and made his adjustments which were read off the back dial by the experimenter in millimeters of error. After making the adjustment, the subject looked away while the experimenter recorded the dial reading and reset the variable line.

Results

The trial means were obtained for combined subjects on each trial of the inverted "T". Similar trial means were also obtained for the "L" figure. The sum of twenty was added to each subject response for computational purposes to eliminate negative numbers. Stem-variable and base-variable figures were combined in both groups to control the variable line effect.

The combined inverted "T" figure means for the 30 subjects on each of the 70 trials are given and graphed in Figure 3. The means for trials 1-60 represent the results of right-eye viewing. The means for trials 61-70 represent the results of left-eye viewing. The measure of illusion is represented on the graphs by millimeters of errors.

The graph in Figure 3 illustrates that for data obtained on the right eye there is a gradient of increasing adaptation or decreasing illusion for trials 1-60. The gradient of increasing adaptation represents a decrease over (x) number of trials of the amount of illusion seen by the subject. The trial data approach, but do not reach zero illusion. The ten trials data obtained on the left eye also illustrate a gradient of increasing adaptation that appears to approximate a hypothetical continuation of the gradient obtained from the 60 trials on the right eye.

Three tests of significance of difference were computed using three groups of ten trials each. These groups are identified on the graph in Figure 3 as A, B, and C. The results of these tests are represented in Figure 5. Significant differences were found between groups A and B, and A and C at the .1% level of confidence. A significant difference was found between groups B and C at the 5% level of confidence. The two-tailed t-test of significance for small groups was used. These t-test results at or below the 5% level of confidence were used as a basis for rejection of the Null hypothesis. This procedure was followed for testing the significance of both the inverted "T" and the "L" figure data.

The "L" figure means for the 30 subjects on each of the 80 trials are given and graphed in Figure 4. The means for trials 1-60 represent the results of right-eye viewing using the temporally-oriented "L" figure. The means for trials 61-70 represent the results of left-eye viewing using the temporally-oriented "L" figure. The means for trials 71-80 represent the results of left-eye viewing using the nasally-oriented "L" figure.

The graph in Figure 4 illustrates that there is a small gradient of increasing illusion for trials 1-60 using the temporally-oriented "L" figure in the right eye. The gradient tends to level off and remain relatively constant from the midpoint of the trials. The ten trials data obtained on the left eye using the temporally-oriented "L" figure illustrate a relatively level measure of performance across a series of ten trials. This ten-trial series is approximately at the same level of illusion as the first ten-trial series using the temporally-oriented "L" figure in the right eye. The data obtained on the left eye using the nasally-oriented "L" figure illustrate a small gradient of increasing illusion across a series of ten trials. This ten-trial gradient represents a higher level of illusion than that found in the first ten trials.

Six tests of significance of difference were computed using four groups of ten trials each. These four groups are identified on the graph in Figure 4 as D, E, F, and G. The results of these tests are presented in Figure 5. Significant differences were found between groups D and E, E and F, E and G, and F and G at the .1% level of confidence. A significant difference was found between groups D and G at the 5% level of confidence. No significant difference was found between groups D and F at the 5% level of confidence.

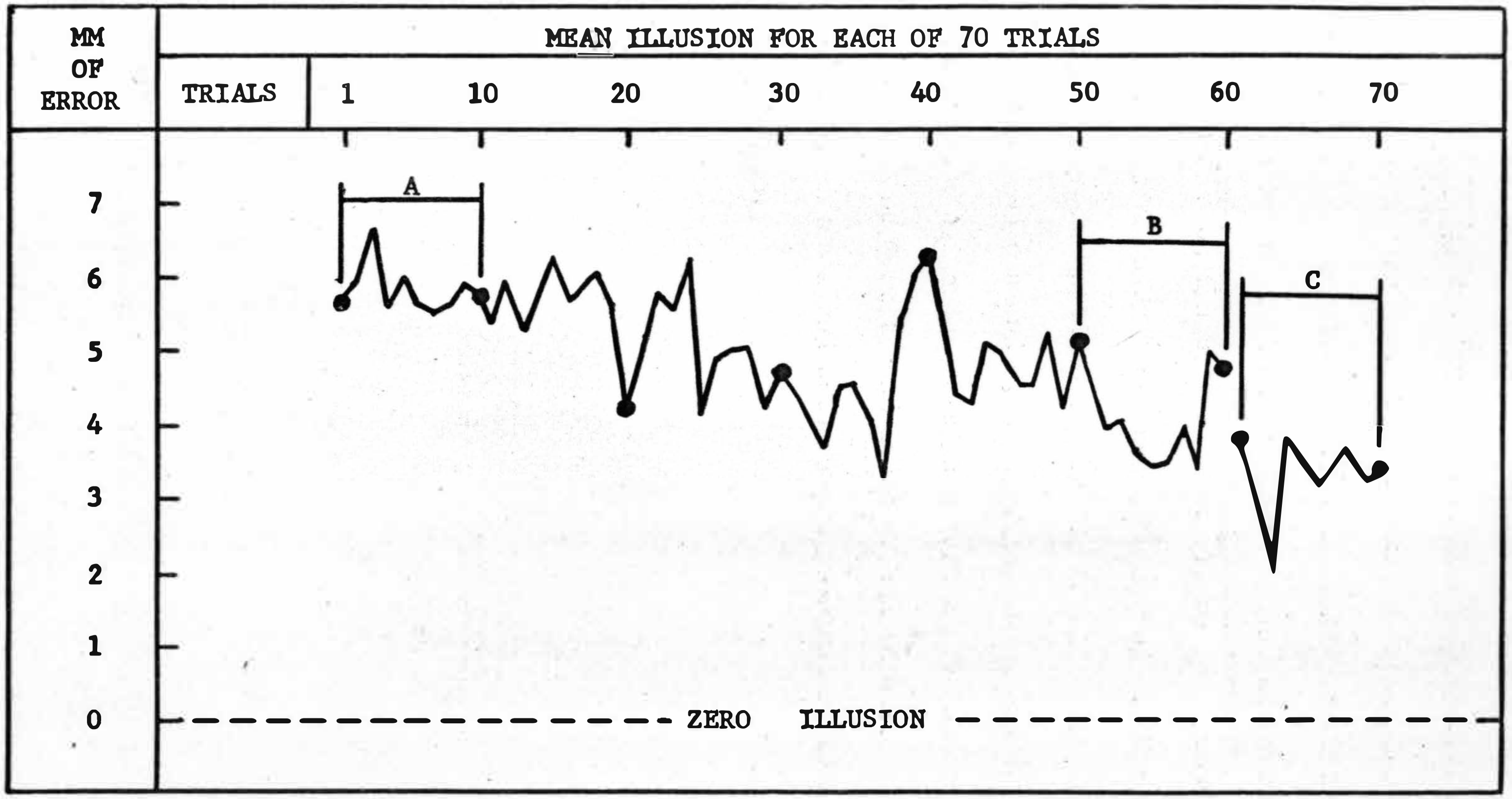


Fig. 3. The combined means for thirty subjects on each of 70 trials with the 50mm. inverted "T" figure.

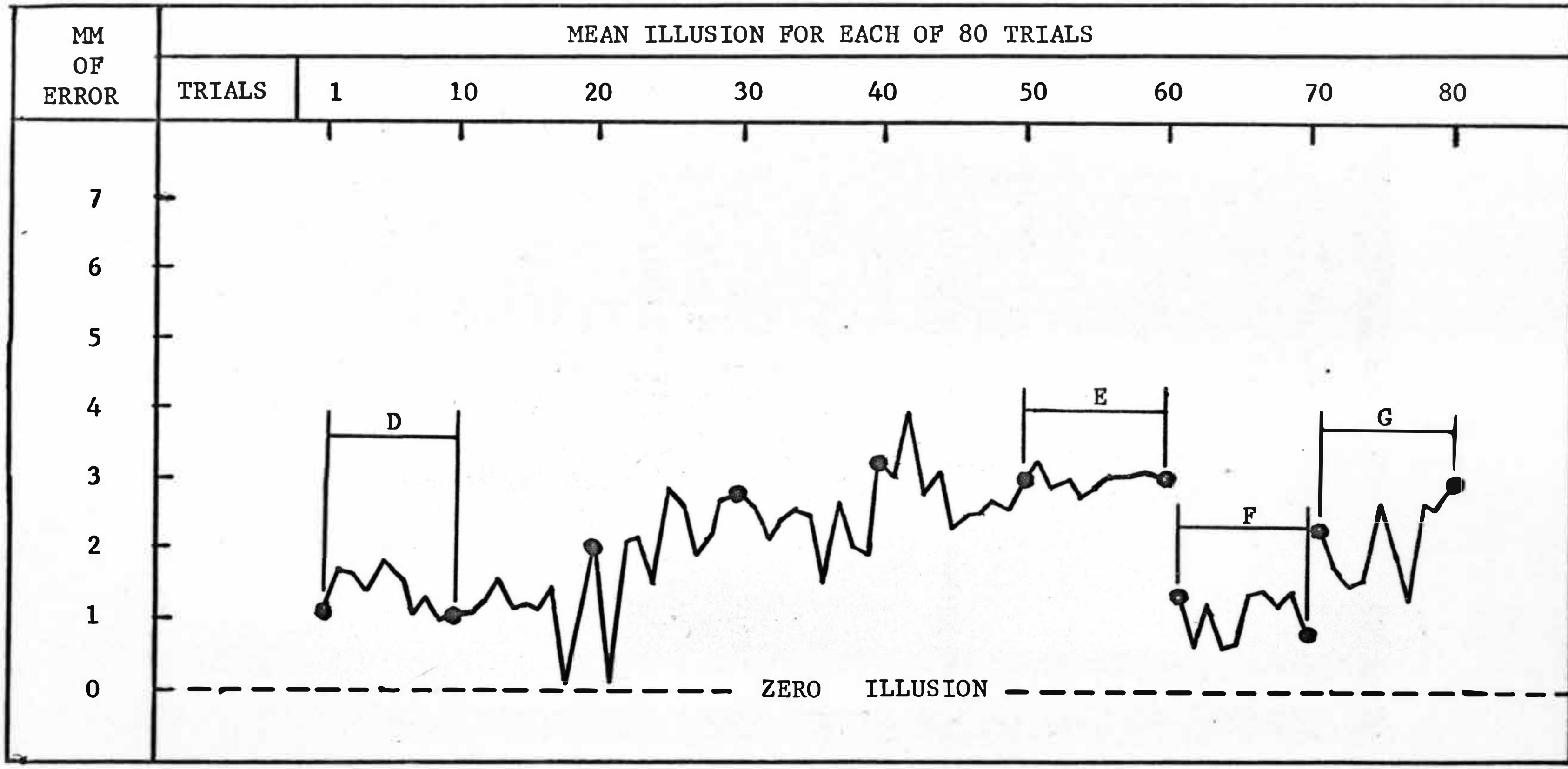


Fig. 4. The combined means for thirty subjects on each of 80 trials with the 50mm. "L" figure.

Groups	Means	Standard Deviations	Groups	t - Test Scores	Level of Confidence
A	25.81	.352	A & B	7.05	.1%
B	24.11	.675	A & C	9.85	.1%
C	23.43	.676	B & C	2.24	5.0%
D	21.37	.294	D & E	14.33	.1%
E	23.07	.233	D & F	2.04	-
F	21.08	.343	D & G	3.72	5.0%
G	22.14	.581	E & F	15.19	.1%
			E & G	4.72	.1%
			F & G	4.96	.1%

Fig. 5. The Means, Standard Deviations, and t - Test Scores for trial groups A to G.

Discussion

The first hypothesis tested by this experiment was that the illusory effect present in the first ten trials with the left eye would equal that found in the first ten trials and exceed that found in the last ten trials with the right eye using the inverted "T" figure.

The purpose of this hypothesis was to test a theory of illusion proposed by the author. This writer theorized that the vertical-horizontal illusion was due to the peripheral characteristics of our monocular field of vision. If this is true then each eye should respond independently to the illusory figure, and no transfer effect should occur between eyes on subsequent viewing trials.

An extended series of trials was run on one eye to allow the eye to adapt to the figure. This period of adaptation resulted in a gradient of decreasing illusion first noticed by Fatzinger (1951). After adaptation by the right eye had occurred, the left eye was used. If the amount of adaptation transfer between eyes is zero, then the illusory effect found in the left eye should have equaled the magnitude originally found in the right eye. This was not found to be true.

The data gathered on the left eye illustrated on the graph in Figure 3, appear to be an approximate continuation of the gradient of decreasing illusion obtained on the right-eye trial series. This finding would tend to indicate that there was a transfer of the effects of a period of adaptation.

The failure to find interocular differences with the inverted "T" figure weakened the support for a theory of illusion based on peripheral characteristics of the monocular field of vision and indicated the possibility of an alternate theory.

The statistical significance tests results obtained supported the visual analysis of the graphed trial data.

The second hypothesis tested by this experiment was that the illusory effect present in the first ten trials with the left eye would equal that found in the first ten trials and exceed that found in the last ten trials with the right eye when using the temporally-oriented "L" figure in either eye, but would be less than the first ten trials with the right eye when using the temporally-oriented "L" figure in the right eye and nasally-oriented "L" figure in the left eye.

The purpose of this hypothesis was twofold. The first was to test a theory stated by Kunnapas (1957) that the nasally-oriented "L" figure was a lower illusory figure than the temporally-oriented "L". The results concerning this finding will be discussed later.

The second purpose was to determine if the temporally-oriented "L" figure in either eye produced the same effect on the factors underlying the vertical-horizontal illusion in the monocular field of vision as did the inverted "T" figure. If the results obtained from the temporally-oriented "L" figure and the inverted "T" figure were similar, then this would indicate that these two figures were comparable. The comparability of these two figures would not be due to the similarity of the figures themselves, but rather to the factor that both maintain the same orientation to the temporal boundary in either eye. This would mean that the left-oriented "L" figure in the left eye and right-oriented figure in the right eye were equivalent figures with respect to the separate monocular fields of vision. This finding would support a peripheral theory of illusion based on the characteristics of the monocular field of vision.

The results were first of all complicated by the failure to obtain a gradient of decreasing illusion over a series of trials using the temporally-oriented "L" figure in the right eye. The gradient was instead reversed and the magnitude of illusion increased gradually. This effect was first noticed by Fatzinger (1951). An explanation of this finding will depend upon further investigation.

The data obtained using the temporally-oriented "L" figure in the left eye did approximate the same level of illusion found initially in the right eye. This finding supported both Kunnapas (1957) and the theory of peripheral illusion proposed by this writer.

Immediately after the temporally-oriented "L" figure series on the left eye, the nasally-oriented "L" figure was exposed to this same eye. The results obtained did not support Kunnapas. The nasally-oriented "L" figure was found to be higher in illusory effect than either of the temporally-oriented "L" figures on the initial trials. This could have partially been due to the design factor, which may have permitted the residual effects of one figure to influence the subjective amount of illusion seen in another figure.

Failure to obtain the expected results with the "L" figure weakened the assumption that the two temporally-oriented "L" figures are equivalent figures. Until the equivalence of these two figures can be substantiated by further research, they cannot be assumed to be comparable to the inverted "T" figures and therefore, cannot be used to support a theory of peripheral illusion as originally stated in this paper.

The results of this study indicated two things to this writer. The factors underlying illusion in the vertical-horizontal line relationship when examined in the monocular viewing field are affected differently by the inverted "T" than by the "L" figure. A theory of illusion based on the peripheral characteristics of the monocular field of vision was not supported by the data obtained using the inverted "T" figure, nor in a satisfactory way by the data obtained using the "L" figure.

Three explanations may be used to explain the failure to obtain the expected results with the nasally-oriented "L" figure. The first possibility disregards the effect of reversing the orientation of the "L" figure. The increase in illusion resulting from using the left-eye, nasally-oriented "L" over the previous level of illusion obtained with the temporally-oriented "L" in the same eye could be due to the presence of a phenomenon similar to the gradient of increasing illusion found in the results of the data on the 60 trials with the right eye. The first ten trials and the second ten trials with the "L" figure in the left eye would constitute a 20 trial series that would approximate the 60 trial series if continued.

The second explanation is that the nasally-oriented "L" figure is a higher illusory figure than the temporally-oriented "L". This is not supported by Kunnapas (1958). At the present there is no basis for either accepting or rejecting these two explanations. However, on the basis of previous research (Kunnapas, 1957, 1958) these explanations are not considered to be very plausible.

The third explanation is believed by the author to be the most accurate and acceptable. This explanation is based on the assumption that the cortex is the location in the visual processes of the factors underlying the vertical-horizontal illusion. If the cortex is the location of the distorting factors that produce the vertical-horizontal illusion, then the orientation of the "L" figure in the monocular field is unimportant. The cortex "sees" the figure either oriented to the right or to the left. The temporally-oriented "L" figure in the right eye and the nasally-oriented "L" figure in the left eye would both be oriented in the same direction when projected onto the cortex. These two figures could then be postulated as equivalent. The results obtained with the nasally-oriented "L" figure would represent a residual effect of the original gradient of increasing illusion obtained with the first right-oriented "L" on the 60 trial series. Therefore, two right-oriented or two left-oriented "L" figures and the inverted "T" figure maintain the same orientation in the cortical visual center when shifted from left-monocular to right-monocular viewing field. Reversing the orientation of the "L" figure in the cortex would result in a change in the previously obtained gradient. This may explain why the trial data obtained using the temporally-oriented "L" figure in the left eye did not fall on a continuum of the gradient of increasing illusion obtained over a series of trials using the temporally-oriented "L" figure in the right eye. The inverted "T" figure always maintains the same orientation in either eye so therefore, the data obtained from both eyes illustrated a continuous gradient. This explanation is offered as a theoretical framework for future research.

The left-extended "L" figure in the right eye and the left-extended "L" figure in the left eye are equivalent figures. Conversely the right-extended "L" figures in either eye are also equivalent. The inverted "T" figures in either eye are also equivalent figures.

A pair of equivalent figures when tested separately should demonstrate similar graphical curves. The data gathered over a series of trials should approximate one continuous graph line if one figure of an equivalent pair of figures is viewed by one eye immediately after the other figure of the equivalent pair is viewed by the other eye.

A suggested experimental design to illustrate these propositions would be comprised of three steps. (1) One figure of an equivalent pair would be presented to the right eye for a number of trials. Next, the second equivalent figure would be presented to the left eye. (2) One figure of an equivalent pair would be presented to the right eye for a number of trials. Next, a nonequivalent figure would be presented to the left eye. (3) One figure of an equivalent pair would be presented to the right eye for a number of trials. Next, a nonequivalent figure would be presented to the same eye.

Summary

Sixty General Psychology students were divided into two groups of thirty. One group viewed the inverted "T" figure 60 times with the right eye and ten times with the left. The other group viewed the temporally-oriented "L" figure 60 times with the right eye, the temporally-oriented "L" figure ten times with the left eye, and the nasally-oriented "L" figure ten times with the left eye. The psychophysical method of average error was used. Each time either the base of the stem of the figure was 50 millimeters in length. The subject's task was to adjust the other variable line until it appeared to be the same length as the 50 millimeter standard line. No knowledge of results was given.

Interocular differences were not found with the inverted "T" figure. The first hypothesis was not supported. A continuous gradient of increasing adaptation indicated a single center of illusion and partially supported a cortical theory of illusion.

The interocular differences found with the temporally-oriented "L" figure supported the second hypothesis. However, the nasally-oriented "L" figure was found to be a higher illusory figure then the temporally-oriented "L" figure. This finding did not support Kunnapas (1958) or the second hypothesis.

A theoretical explanation based on a cortical location of illusion was presented. Acceptance of this theory requires that the "L" figure be thought of in terms of nasal or temporal orientations. The nasal "L" figure in the left eye and the temporal

"L" figure in the right eye are believed to be equivalent figures. A different experimental design is needed to handle this new spatial perspective of the "L" figure. The residual effects of illusion adaptation must be taken into account if equivalent figures are used successively in the right and left eyes.

APPENDIX A

Instructions to the Subject

First part of experiment. - You will be required in this experiment to make the proper adjustment so that the two lines appear to you to be equal. Each setting will be a separate trial. Try to do your best, but do not try to beat the game by making compensating guesses; this will only defeat the purpose of the experiment and waste your time and mine.

The procedure is as follows. If you normally wear glasses for near vision or interocular differences, you may wear them now. When you look into the box you will see two fluorescent green lines in either an inverted "T" or an "L" figure. One line of the figure will either be too long or too short. Your job is to turn the knob adjacent to the eye piece until the two lines appear to be equal in length.

When you are satisfied with your setting, say "OK" and look away until I tell you to proceed with the next setting. Remember now, your task is to compare the whole base line to the whole stem line and adjust these lines until they appear to be equal. You may use all the time that you feel necessary to arrive at a satisfactory setting. You will be required to use only your right eye.

Do you have any questions? If not, you may proceed with the first setting.

Second part of experiment. - (Directions applicable to both the inverted "T" and the "L" figure) You will now be required to follow the same procedure you have been following, but using your left eye exclusively.

Third part of experiment. - (Directions applicable to the "L" figure only) You will now be required to follow the same procedure you have been following, still using your left eye only.

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