The influence of perceptual anchors and visual noise on the vertical-horizontal illusion¹

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In an earlier study Chapanis and Mankin examined the vertical-horizontal illusion in a visually-rich environment. In that study they felt that perceptual anchors and visual noise may have influenced the Ss' estimates of the real-world objects that were used as stimuli. The present experiment attempted to test in a controlled laboratory environment the questions raised in the previous experiment. In the present experiment Ss were asked to estimate the height of a vertical stimulus line by indicating its corresponding horizontal distance. The vertical stimulus line was presented in a background of visual noise and potential anchors. The results indicate that the anchors did influence estimates and that this influence was, in turn, affected by the visual noise.

Illusions are very much a part of our perception of the everyday world. Because of them we frequently make errors in our judgments of length, area, direction, curvature, distance, and number. Such errors are normal in the sense that they are experienced by most of us in our attempts to organize the large amount of stimuli that constantly bombard our senses. Psychologists have attempted to explain illusions for many reasons, not the least important of which is that they may provide clues to the basic processes of perception. The vertical-horizontal illusion, in which vertical lines are generally judged to be longer than horizontal lines of equal length, is one illusion that has received its share of such speculations.

Of the many attempts to account for this illusion, the explanation proposed by Theodor Künnapas seems to be the most plausible. In one of his experiments (1955b) Künnapas showed that the closer the boundary of a field lies to the edge of a line, the more likely it is that the extent of the line will be overestimated in that direction. He postulates that the explanation of the vertical-horizontal illusion lies in the oval shape of our visual field with its shorter vertical dimension. The relative "nearness" of the vertical line to the boundary results in its overestimation as compared to the horizontal line. He provided some support for this hypothesis (1957) by demonstrating that the illusion decreases significantly in complete darkness. He has also shown (1958) that when the head is tilted 90 deg to one side, the vertical overestimation changes into underestimation. In still another experiment (1959) he was able to vary the ratio of the horizontal to the vertical axis of the visual field by the use of specially constructed spectacles. Under these conditions he found that the amount of vertical overestimation varied inversely with the ratio of the vertical to the horizontal dimensions. That there is more to the illusion than can be accounted for by Künnapas's theory, however, is suggested by the fact that under no conditions was he able to produce an *underestimation* of a vertical distance.

In all of Künnapas's experiments and most of those done by other investigators, the stimulus objects have consisted of straight, well-formed lines on plain backgrounds. Few attempts have been made to examine the influence of other factors that may be encountered in our everyday observation of real-world objects. For example, we rarely see well-drawn straight lines on plain backgrounds with every trace of context eliminated. It is at least possible that factors other than the shape of our visual field, e.g., size, context, and size constancy, may affect our perception of objects in a visually-rich environment.

A few experimenters have investigated the effects of object shape on the vertical-horizontal illusion. Pan (1934) was one of the first to suggest the influence of the particular shape of the objects themselves upon the perception of their vertical heights. Somewhat later, Sleight and Austin (1952) were able to demonstrate the illusion with squares and rectangles, but not with circles and ellipses. Although they examined only a few simple forms, their data clearly suggest the importance of contextual cues in the stimulus pattern itself.

The dearth of material relating the vertical-horizontal illusion to perception in the real world prompted Chapanis and Mankin (1967) to study the vertical-horizontal illusion in a visually-rich environment. In that experiment, Ss were required to estimate the vertical heights of 10 real-world objects by indicating where the top of each object would fall if it were tipped on its side. To explain the large amount of variation in the mean estimates made of the various objects, two factors, anchor points and visual noise acting in combination with each other, were tentatively identified as influencing the illusion.

The influence of anchor points was suggested by the fact that the variances of the estimations for three of the objects were significantly smaller than those for the other seven. In addition, these three objects showed the smallest (or even a negative) illusory effect. It has been shown by Nash (1964), Volkmann (1951), Stevens and Galanter (1957), and Carr and Garner (1952), that errors and variations of response decrease in the neighborhood of anchors. It appeared likely then, that Ss' responses were being anchored by stimuli in the backgrounds of the objects.

The question remained, "Why did anchors influence the estimations of only three objects, even though all of the objects were imbedded in contexts rich enough to produce abundant opportunity for anchoring?" Closer examination of the particular objects involved led to the hypothesis that the position of the anchor and the amount of context in which it was imbedded were the determining factors. The specific conjecture was that for a stimulus to act as an anchor, it must lie somewhere in the area where the Ss would normally be making their estimates. In addition, the objects for which the illusion seemed relatively uninfluenced by anchoring effects were richer in context than the other objects. In these cases potential anchoring stimuli may have been masked by the large amount of visual noise in the backgrounds of these objects.

Since the Chapanis-Mankin experiment was not designed to test these particular points, the authors could not arrive at any definite conclusions about them. The purpose of the present experiment was to test these speculations. Specifically, this experiment was designed to answer these questions:

Fig. 1. All stimuli contained the basic stimulus pattern pictured above. This pattern, along with the anchors, was imbedded in various levels of visual noise to produce the stimuli used in this experiment.

(1) How is the vertical-horizontal illusion affected by the position of potential anchoring stimuli?

(2) Does the influence of these anchor stimuli vary with the amount of context (i.e., visual noise) in which they are imbedded?

METHODS

Stimuli

All stimuli included the same basic stimulus pattern (Fig. 1). This consisted of a thin, black, horizontal line (referred to as the "reference line" throughout the rest of this paper), and a slightly thicker vertical line, the "stimulus line." The reference line was centered on a white sheet of 8½ in. x 14 in. stiff-back paper and extended the width of the sheet. The stimulus line was located 1½ in. from the right-hand edge of the sheet. It started on the reference line and extended 3½ in. above it.

The basic stimulus patterns were imbedded in various amounts of random visual noise, made up of black dots approximately 1/16th of an inch in diameter. The four levels of noise consisted of 0 (no noise), 50, 700, or 1400 dots distributed randomly over the sheet. The coordinate positions for the dots were computer-generated. One constraint was put on the random placement of the dots; no dots were located on or touching either the stimulus or reference lines, except for the anchor dots described below.

The eight anchor conditions were as follows:

- (1) Zero anchor, i.e., no dots on the reference line.
- (2) A dot on the reference line 1½ in. to the left of the vertical line.
- (3) A dot on the reference line 3¼ in. to the left of the vertical line.
- (4) A dot on the reference line 3½ in. to the left of the vertical line.

Fig. 2. Stimulus patterns P16 and P27.

Table 1
The Stimuli Used in this Experiment

Noise Condition	Number of Dots	Anchor Condition							
		1	2	3	4	5	6	7	8
1	0	P11	P12	P13	P14	P15	P16	P17	P18
2	50	P21	.....	.....	.....	.....	.....	.....	P28
3	700	P31	.....	.....	.....	.....	.....	.....	P38
4	1400	P41	.....	.....	.....	.....	.....	.....	P48

(5) A dot on the reference line 3¼ in. to the left of the vertical line.

(6) A dot on the reference line 7½ in. to the left of the vertical line.

(7) A dot on the reference line 9½ in. to the left of the vertical line.

(8) Multiple anchors, i.e., two dots on the reference line at the positions of Anchors 4 and 7.

The eight anchor conditions were combined with each of the four noise levels to yield a total of 32 different stimuli. Within each noise level the number of dots, the position of the anchor, and the basic stimulus pattern were the same, but the random location of the dots differed from stimulus to stimulus. Four of the stimuli, one for each level of noise, are illustrated in Figs. 2 and 3. Table 1 summarizes the stimuli and gives the designations that will be used to describe them throughout the remainder of this paper.

Apparatus and Procedure

The experimental apparatus included a large wooden panel mounted vertically on a table several feet in front of the S. In the panel, at approximately eye level, was a window through

Fig. 3. Stimulus patterns P31 and P44.

which the stimuli were presented. The stimuli always appeared centered in the window. Covering the window was a sliding shutter. Behind the shutter was a thin, black, vertical cursor. The cursor was centered on a movable Plexiglas sheet and was 1 in. in height. The cursor intersected and was in turn bisected by the reference line of the stimulus. The starting position of the cursor was approximately $\frac{1}{2}$ in. from either the right- or the left-hand edge of the window depending on the test trial. Fig. 4 illustrates this situation for a given trial as seen by the S. Directly in front of the S on the table at which he was seated was a small panel containing a push button and a control knob. The control knob operated a remote control synchronous motor that in turn varied the position of the cursor.

The onset of each trial was marked by the E opening the shutter in the window, exposing a stimulus. The S's task was to position the cursor along the reference line so that the horizontal distance measured from the stimulus line to the cursor equalled the height of the stimulus line. This distance was always marked off to the left of the stimulus line. The S was allowed as much time and as many adjustments in either direction as were necessary. When he was satisfied with his estimate, he pressed the button in front of him automatically closing the shutter. The shutter remained closed until the next presentation at which time the procedure was repeated.

The position of the stimuli in the window was varied randomly from trial to trial within a small range ($\frac{3}{4}$ in.). These changes were intended to force the S to pay attention to the stimulus and to prevent him from making stereotyped settings by memorizing and resetting the same position of the knob from trial to trial.

At the end of the session, the Ss were asked to make general comments about the experiment. They were also asked whether they had been influenced in their estimates by anything other than the height of the stimulus line.

The total test session lasted from 45 min to 1 h.

Subjects

The Ss were 16 male undergraduate students of The Johns Hopkins University who were paid for their services.

Design

All stimuli were presented one at a time to each S in a repeated-measures design. There were three blocks of trials for each S, each block containing all 32 stimuli. This division was made primarily so that practice effects could be evaluated; it did not involve an actual interruption of the test session. The orders of presentation were randomized separately for each block and counterbalanced, such that for any given trial across all Ss, each of the eight anchor conditions was presented twice and each of the four noise levels was presented four times.

The starting position of the cursor was always the same for every trial within a block of 32 trials but was switched to the opposite side of the window for each successive block of trials. Coincident with this switch was a change in the direction of rotation of the control knob necessary to make an estimate. For example, when the starting position of the cursor was to the right as illustrated in Fig. 4, a counterclockwise rotation of the control knob was required to move the cursor to an approximate estimate (in this case, to the left). A clockwise rotation was required when the starting position was near the left-hand edge of the window. The starting position was counterbalanced across all Ss.

Treatment of the Data

Errors were recorded to the nearest five-tenths of a millimeter. An overestimation was recorded as a positive error and an underestimation was recorded as a negative error.

Fig. 4. The experimental situation as seen by the S at the start of a given test trial. For the trial illustrated here the cursor is to the right of the stimulus line.

RESULTS

Errors of estimation were averaged across Ss and blocks of trials to yield a mean error of estimation for all 32 stimuli. These means are given in Table 2. The row and column means show the average error for each noise and anchor condition, respectively.

The overall mean error averaged across Ss, blocks of trials, anchors, and noise levels was +0.22 cm or an overestimation of slightly less than 2.5% (see Table 3). This mean was not significant. Most experiments on the vertical-horizontal illusion show overestimations of about 7-8% (see Finger & Spelt, 1947). Even estimations of the vertical stem of L-shaped figures, which bear a closer resemblance to the *basic stimulus patterns* in this experiment, usually show a positive error of about 5% (see Kunnappas, 1955a).

The overall mean error in this experiment is an agglomeration of all the influences on the illusion both intentionally and unintentionally designed into the experiment. For this reason, the overall mean is not the best measure to compare directly with other similar research. The zero anchor, zero noise (P11) stimulus, however, does closely approximate the conditions typically used in studies of this illusion. In this instance there should be a pure illusory effect uncontaminated by influences attributable to either noise or anchors. The mean error for this condition is +0.36 cm or approximately 4% (see Table 3). This error is not significant and is still less than has been found in other studies. Reasons why this may have occurred will be considered in some detail in the discussion section of the paper.

In the analysis of variance on the errors of estimation (see Table 4), the sums of squares for the main anchor effect and all interactions involving an anchor effect were subdivided into the following components:

- (1) The variation that can be attributed to the different positions of the *single* anchor only (i.e., Anchor Conditions

Table 2
Mean Errors of Estimation (cm) Averaged Across Subjects and Blocks of Trials. Each Entry in the Body of the Table is Based on 48 Measures.

Noise Condition	Number of Dots	Anchor Condition								Mean
		1	2	3	4	5	6	7	8	
1	0	.36	.10	-.10	.07	.30	.43	.54	.18	.24
2	50	.33	.44	.12	.13	.28	.30	.23	.12	.24
3	700	.19	.29	-.04	.09	.34	.20	.27	.05	.18
4	1400	.24	.45	.03	.19	.20	.29	.23	.30	.24
Mean		.28	.32	.00	.12	.28	.30	.32	.16	.22

Table 3
Mean Errors of Estimation for all Patterns and for P11

Subject	All Patterns	P11
1	0.93	1.38
2	-0.19	.25
3	-0.55	-.40
4	-0.64	-.58
5	-0.88	-.33
6	1.54	2.00
7	-0.46	-.97
8	1.41	1.78
9	0.71	.60
10	0.98	.98
11	0.44	.75
12	-0.25	-.20
13	0.38	.57
14	-0.05	-.43
15	0.29	.30
16	-0.08	.10
Mean	0.22	0.36
t	1.22	1.72
df	15	15
Significance	NS	NS

2 through 7). This was computed by an analysis of variance on the data for the six single anchor conditions only. This analysis is in addition to the one performed on all of the data.

(2) The residual variance calculated by subtracting the sums of squares for the single anchor position analysis [see (1) above] from the overall analysis for each corresponding source of variation. In Table 4 this is always indicated as A_N . The single anchor position component is always indicated as A_P .

These analyses indicate that there is a highly significant main effect due to the position of the single anchor ($p < .001$). None of the other main effects is significant.

The interaction of visual noise with the single anchor positions was also significant ($p < .01$). This interaction is illustrated by the portion of Fig. 5 that summarizes the errors for Anchor Conditions 2 through 7.

As mentioned in the introduction, anchors characteristically reduce the variability of responses. It was with this in mind that Chapanis and Mankin (1967) ran an analysis of variance on the variances of their estimations. From the results of that analysis they were able to infer that anchors were operating in the estimations made of some of their stimulus objects. A similar analysis was performed in this experiment but the results were not significant.

DISCUSSION

The purpose of this experiment was to examine some of the speculations raised in the study by Chapanis and Mankin (1967). The authors felt that in that experiment many Ss had utilized contextual stimuli to anchor their estimates of the heights of certain stimulus objects. They also felt that two of the main variables that determined whether a stimulus would act as an anchor were the position of the anchoring stimulus and the amount of visual noise in which it was imbedded. The stimuli in the present study were intended to simulate in a laboratory setting the stimulus situation of the previous study.

The first prediction made in the present study was that the position of certain of the experimentally-defined anchors would influence the S's estimates of the height of the stimulus line. Specifically, Anchor Conditions 3, 4, and 8, all located in the vicinity of the S's estimates, were expected to produce smaller mean errors of estimation and less variability in response than the others. In fact, there was a significant main effect due to the anchor position in the analysis on the means,

but this effect was not significant in the analysis on the variances. The mean errors for Anchor Conditions 3 and 4 are significantly lower ($p < 0.001$ and $p < 0.02$, respectively) than the error for the zero anchor condition (the appropriate control condition). The mean for Condition 8 was the next smallest mean and is also less than the zero anchor condition, but the difference is not significant. The other anchor conditions did not differ significantly from the zero anchor condition.

One might also suppose that Anchor Condition 5 should have had some anchoring influence as it is also in the vicinity of the Ss' estimates. However, even if there were an effect due to Anchor 5 it was not expected to show up as a reduced mean error for this anchor condition. The reasons for this are as follows: The illusion should cause Ss to locate their estimates of the vertical stimulus line slightly to the left of the corresponding horizontal distance. The influence of the anchors at 3 and 4 was to draw estimates to them, compensating for the illusion and resulting in smaller errors than in the other conditions. The anchor at 5, however, was at a distance approximately equal to the expected illusory effect, and so would not be expected to influence the mean errors significantly.

In response to the questions asked them at the end of the experimental session, 13 of the 16 Ss said that they noticed the nonrandom placement of the dots on the horizontal reference line. It is possible that the other three Ss may also have noticed the dots, but didn't feel it was worth mentioning. Of the 13, 10 Ss said that they made a conscious effort either

Table 4
Analysis of Variance of Errors of Estimation

Sources of Variation		Degrees of Freedom	Mean Squares	F Ratios
1	Between Subjects (S)	15	51.900	
2	Between noise levels (N)	3	0.391	1.71
3	Between anchor conditions (A)	7	2.591	
	A. Between numbers of anchors (A_N)	2	0.722	2.39
	B. Positions of the single anchor (A_P)	5	3.338	8.95†
4	Between blocks of trials (B)	2	5.667	1.24
5	Interaction: S x N	45	0.229	
6	Interaction: S x A	105	0.355	
	A. Interaction: S x A_N	30	0.311	
	B. Interaction: S x A_P	75	0.373	
7	Interaction: S x B	30	4.589	
8	Interaction: N x A	21	0.569	
	A. Interaction: N x A_N	6	0.295	1.17
	B. Interaction: N x A_P	15	0.679	2.69*
9	Interaction: N x B	6	0.253	< 1
10	Interaction: A x B	14	0.183	
	A. Interaction: A_N x B	4	0.260	1.09
	B. Interaction: A_P x B	10	0.152	< 1
11	Interaction: S x N x A	315	0.219	
	A. Interaction: S x N x A_N	90	0.252	
	B. Interaction: S x N x A_P	225	0.206	
12	Interaction: S x N x B	90	0.280	
13	Interaction: S x A x B	210	0.240	
	A. Interaction: S x A_N x B	60	0.239	
	B. Interaction: S x A_P x B	150	0.240	
14	Interaction: N x A x B	42	0.216	
	A. Interaction: N x A_N x B	12	0.232	1.09
	B. Interaction: N x A_P x B	30	0.209	< 1
15	Interaction: S x N x A x B	630	0.242	
	A. Interaction: S x N x A_N x B	180	0.213	
	B. Interaction: S x N x A_P x B	450	0.253	
16	Total	1535		

† $p < 0.001$

* $p < 0.01$

to ignore the dots or to avoid placing their estimates directly on them. Several Ss also described the effect of the dots as "confusing." It may be, therefore, that the dots at or near the equality position, i.e., those in Positions 3 and 4, drew the S's estimates in the direction of the dots. Confusion or uncertainty caused by the presence of the dots, however, may have made the Ss variable in their estimations. Such an explanation would account both for the reduction in the mean estimates and for the lack of a reduction in their response variability.

The failure of the mean for the zero noise and zero anchor stimulus (P11) to reach significance is another discrepancy from expectation that requires further examination. This result is disappointing in that this is one of the few experiments of this type that has not demonstrated a clear-cut overestimation of vertical lines.

There are two possible explanations for the lack of a significant demonstration of the illusion in this experiment. The first and most obvious explanation is that the experimental error may have been inflated by the apparatus used in the experiment. Many Ss did comment that it was often difficult to set the cursor very accurately because the response of the control knob was uncertain and "mushy." It may be possible with better equipment to decrease the amount of experimental error to the point where the mean error of estimation for P11 would be significant. However, inflated experimental error cannot account for the fact that the mean vertical overestimation in this experiment is still substantially less than the overestimation demonstrated in other, similar experiments.

An alternative (or additional) explanation is that the stimuli used here may not have been comparable to the stimuli used in previous studies of the vertical-horizontal illusion. In these other studies the stems of the vertical-horizontal figures have usually been restricted in length, i.e., the stems terminate well before they reach the edge of the visual field. In this experiment, however, the horizontal reference line extended to the window which, in effect, determines the extent of the visual field. It may be that this basic difference between the stimuli used in this experiment and the figures of the previous experiments is responsible for the different amounts of vertical overestimation. In any case, this question must remain unanswered and a subject for further research.

The second major prediction, that the anchor effect would be masked by increasing the level of visual noise, was confirmed but not in the way that had been anticipated. There is a significant interaction between levels of noise and anchor positions (N by Ap) among the means (see Table 4), but not among the variances. The reasons for the lack of a significant interaction effect in the analysis of variance on the variances are possibly the same reasons there was no significant anchor position effect in this analysis.

The source of this interaction (see Fig. 5) seems to arise in most part from Stimuli P12 and P17. The original hypothesis was that only the equality and near equality anchors should influence estimates and that this influence would be masked by increased levels of visual noise. This would have resulted in large interaction effects from Stimuli P13, P14 and P15—an expectation that was not confirmed by the data. An examination of Fig. 5, and the means in Table 2, suggests that the distant anchors also influenced estimates and it is *this* influence that was masked by the visual noise.

These results and a further examination of the Ss' responses to the postexperimental questions lead the E to propose a tentative hypothesis as to just what the nature of the anchor effect in this experiment may have been.

The instructions given to a S at the beginning of the test session made no mention of anchors. He was told only that the basic stimulus pattern would be imbedded in a background of

Fig. 5. Mean errors of estimation for all of the 32 stimuli tested in this experiment.

randomly placed dots. Typically, however, the S very early in the experiment noticed that a dot (or dots) was often on the reference line. This occurred too often for the S to believe it was random. It may be that with zero noise all the anchors were quite salient regardless of how far from the equality position they were. The equality and near-equality anchors may have remained salient at the higher levels of noise because they were always at, or near, the S's focus of attention, i.e., the area in which he made most of his estimates. On the other hand, the higher levels of noise may have masked the *distant* anchors because they were peripheral to the S's focus of attention.

The influence of anchors not in the immediate vicinity of target stimuli (i.e., "distant" anchors) is not a new phenomenon (see Attneave, 1955; Taylor, 1961). The reason why it had not been anticipated in this experiment is that predictions were made on the basis of the previous experiment and not from the specific situation that existed in the present one. In the earlier experiment the Ss always made their observations at a distance equal to $2\frac{1}{2}$ times the height of the stimulus object. In the present experiment the Ss were at a distance greater than 10 times the height of the stimulus line. An anchor at a distance of $2\frac{1}{2}$ times the height of the stimulus object was closer to the periphery of the visual field in the previous experiment and so probably less noticeable. In the present experiment, however, because of the smaller visual angle subtended by the stimulus line (and the smaller visual angle subtended by its corresponding horizontal distance), a so-called distant anchor is relatively much closer to the focus of attention. All of this, of course, is only speculation and it is only one of several possible explanations for the data of this experiment.

The discrepancies between the expected and actual results illustrate an important point that can be made about many other experiments of this type. The original objective of this research was to test some speculations arising from the results of an earlier experiment. This earlier experiment had been conducted in the "real world" and the present experiment was an attempt to simulate and abstract certain aspects of that situation and to examine them under well-controlled laboratory conditions. However, the present experiment was

necessarily artificial and contrived and was not completely successful in its representation of the real world. Because the predictions were made on the basis of the real-world experiment rather than from the particular stimulus situation that developed in this experiment, the discrepancies from expectation may indicate that the E has been unsuccessful in his attempt to simulate the previous experiment. To take only one illustration, the visual noise in this experiment was made up of dots all of the same size. Visual noise in the real world is almost never that simple. Of course, it is always possible that the original hypotheses proposed by Chapanis and Mankin about what was happening in the real world were wrong. In any case, some interesting relations between perceptual anchors, visual noise, and the vertical-horizontal illusion are indicated.

In addition, this experiment did demonstrate the difficulty of abstracting meaningful laboratory experiments from the real world and even more important, the difficulty encountered when we try to generalize from the laboratory to the everyday world—a point already well made by other Es (e.g., Chapanis, 1967).

SUMMARY

This experiment was designed to test some speculations arising from an earlier study by Chapanis and Mankin in which Ss were asked to estimate the heights of 10 real-world objects by indicating their corresponding horizontal distance. The results suggested that anchors influenced the estimates for certain of the objects. To explain why anchoring occurred for only some objects the authors speculated that a potential anchor must be in the vicinity of an estimated position to influence the estimate. They also felt that if potential anchors were imbedded in a large amount of visual noise they would be masked and consequently have little or no effect on the estimates.

The present experiment attempted to test these speculations in a controlled laboratory experiment. The vertical object to be estimated was a thin, straight stimulus line located near one end of a horizontal reference line. The anchors were black dots located at various places on the horizontal line and the visual noise consisted of black dots distributed randomly throughout the background. The stimulus line and reference line were combined orthogonally with four levels of noise and eight anchor conditions to make up the 32 stimuli used in the experiment. These stimuli were presented to each of 16 Ss in a repeated-measures design. The Ss' task was to estimate the height of the stimulus line by indicating the corresponding horizontal distance.

The results indicate that the anchors did influence estimates. The anticipated interaction of anchors with noise

level also arose but its source was unexpected. Discrepancies from expectation are attributed to the fact that the stimuli were not representative of either the situation in the previous experiment or the situation in other experiments on the vertical-horizontal illusion.

REFERENCES

- ATTNEAVE, F. Perception of place in a circular field. *American Journal of Psychology*, 1955, 68, 69-82.
- CARR, W. J., & GARNER, W. R. The maximum precision of reading fine scales. *Journal of Psychology*, 1952, 34, 85-94.
- CHAPANIS, A. The relevance of laboratory studies to practical situations. *Ergonomics*, 1967, 10, 557-577.
- CHAPANIS, A., & MANKIN, D. A. The vertical-horizontal illusion in a visually-rich environment. *Perception & Psychophysics*, 1967, 2, 249-255.
- FINGER, F. W., & SPELT, D. K. The illustration of the horizontal-vertical illusion. *Journal of Experimental Psychology*, 1947, 37, 243-250.
- KÜNNAPAS, T. M. An analysis of the vertical-horizontal illusion. *Journal of Experimental Psychology*, 1955a, 49, 134-140.
- KÜNNAPAS, T. M. The influence of frame size on the apparent length of a line. *Journal of Experimental Psychology*, 1955b, 50, 168-170.
- KÜNNAPAS, T. M. The vertical-horizontal illusion and the visual field. *Journal of Experimental Psychology*, 1957, 53, 405-407.
- KÜNNAPAS, T. M. Influence of head inclination on the vertical-horizontal illusion. *Journal of Psychology*, 1958, 46, 179-185.
- KÜNNAPAS, T. M. The vertical-horizontal illusion in artificial visual fields. *Journal of Psychology*, 1959, 47, 41-48.
- NASH, H. The judgment of linear proportions. *American Journal of Psychology*, 1964, 77, 480-484.
- PAN, S. The vertical-horizontal illusion. *N.C.J. Psychol. nat. cent. Univ.*, 1934, 1, 125-128.
- SLEIGHT, R. B., & AUSTIN, T. R. The horizontal-vertical illusion in plane geometric figures. *Journal of Psychology*, 1952, 33, 279-287.
- STEVENS, S. S., & GALANTER, E. H. Ratio scales and category scales for a dozen perceptual continua. *Journal of Experimental Psychology*, 1957, 54, 377-411.
- TAYLOR, M. M. Effect of anchoring and distance perception on the reproduction of forms. *Perceptual & Motor Skills*, 1961, 12, 203-230.
- VOLKMANN, J. Scales of judgment and their implications for social psychology. In J. H. Rohrer and M. Sherif (Eds.), *Social psychology at the crossroads*. 1951. Pp. 273-294.

NOTES

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