

ADAPTATION, AFTER-EFFECT, AND CONTRAST
IN THE PERCEPTION OF TILTED LINES. II.
SIMULTANEOUS CONTRAST AND THE
AREAL RESTRICTION OF THE
AFTER-EFFECT

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INTRODUCTION

The preceding paper has reported the fact that visual lines undergo what may be termed adaptation followed by a negative after-effect with respect to their direction or orientation in the frontal visual field.¹ A line possessing the characteristic of *tilt* appears to become less tilted during the course of a continued inspection, and thereafter a line objectively vertical or horizontal appears to be tilted in the opposite direction. In many respects the adaptation behaves like sensory adaptation of the sort exhibited by color and temperature. Furthermore the preliminary observations suggested that the negative after-effect behaved like a negative after-image in being confined to the stimulated portion of the retina. It did not seem to produce any tilt of the visual field as a whole nor any disturbance in the subject's posture but was instead probably restricted largely to vertical and horizontal lines of approximately the same locus and visual angle as the tilted stimulus-line.

In order to demonstrate that linear direction is functionally akin to a sensory process like that of color, two further investigations need to be made. It might be possible, first, to demonstrate the occurrence of simultaneous contrast in this type of perception. And second it should be shown conclusively that the process of adaptation is a localized process within the visual field. For if the vertical and

¹ James J. Gibson and Minnie Radner, Adaptation, after-effect and contrast in the perception of tilted lines. I. Quantitative studies, this JOURNAL, 1937, 20, 453-467.

horizontal axes can be temporarily shifted by a process of adaptation in one visual region, say of 10° visual angle, and at the same time remain unaffected in outlying regions, then it would scarcely be possible to argue that the effect was merely an 'illusion of judgment' or a type of 'ambiguous perception.' Furthermore, such a demonstration would distinguish the effect from those experiments having to do with the supposed cues which make possible the 'perception' of the visual vertical. The visual field as a whole possesses as one of its primary characteristics an implicit vertical-horizontal frame of reference, and the determinants of this total frame of reference have been sought in a number of theories. Kinæsthetic and equilibratory mechanisms undoubtedly play a role in this determination, along with visual factors. But the study of local and seemingly autonomous modifications of the subjective axes would be an independent problem demanding investigation in its own right.

I. SIMULTANEOUS CONTRAST IN THE PERCEPTION OF LINEAR TILT

It was argued in the preceding report that a visual line or segment could be said to have two fundamental qualities, shape (curved or straight) and direction (vertical, horizontal, or tilted). Both of these qualities manifest successive contrast, and curvature shows simultaneous contrast.² If the analogy is complete, tilt should also show simultaneous contrast.

Many everyday observations support the hypothesis of simultaneous tilt-contrast. On a street which runs sharply up hill it is often noticeable that objectively horizontal lines—the foundation lines of the houses for example—appear to tilt against the incline. Against the perceptibly tilted wall in a room of an old house which has settled to the right, a plumb-line may appear not vertical but slightly tipped to the left. It is not surprising therefore that if one draws a 30 cm line in the middle of a sheet of cardboard squarely in line with the

² J. J. Gibson, *Adaptation, after-effect, and contrast in the perception of curved lines*, this JOURNAL, 1933, 16, 15 f.

upright edges, and then overlays it with 40 cm parallel lines at an inclination of about 10° , the line no longer looks vertical (or horizontal). A slight opposite tilt has been induced, and the line does not now appear normally oriented within its frame. It should be remarked that the induced tilt is not effective for the entire visual field or even for the edges of the cardboard but instead is confined largely to the line.

For the purpose of measuring this induced tilt, the apparatus already described in the first paper was used with only one addition.³ A tilted grille or grating of parallel black lines was introduced into the circular field of the subject 5 cm in front of the white disk which bore the adjustable black line on the white field. The grille was made of strips of black paper $\frac{1}{2}$ cm wide and 4 cm apart fastened to a circular frame outside the field of view. The subject could be required to set the adjustable line to vertical before and after the tilted grille had been superposed on it, or better, could make adjustments with the grille tilted alternately to the right and to the left, the factor of constant error being thereby avoided.

Since we wished to know the amount of tilt-contrast produced by different inclinations of the grille, three degrees of inclination were studied, 10° , 20° , and 45° to right or left of the vertical. It was also desirable to know whether the grille would induce an effect when the line was horizontal as well as when the line was vertical so measurements of both were made. For each subject, 12 adjustments of the vertical and 12 more of the horizontal were made at each inclination, of which 6 were with the grille to the right and 6 with the grille to the left. Four subjects went through the experiment. Individual adjustments of the line were made from a starting point 5° off the reference-axis, alternately to right and left.

The results are given in Table I. The averages at the bottom of the table show in the first place that with the grille tilted at 10° there is a definite contrast-effect on a vertical line. In other words, if the line seen through the grille is to appear vertical to the subject it must be set in a position tilted about

³The data of this experiment were obtained by Miss Doris Robinson in collaboration with the writer.

TABLE I
AMOUNT OF CONTRAST IN DEGREES AT THREE DIFFERENT INCLINATIONS OF THE
INDUCING GRILLE ON THE VERTICAL AND ON THE HORIZONTAL AXIS

Subj.	10° R. or L.		20° R. or L.		45° R. or L.	
	Vert.	Horiz.	Vert.	Horiz.	Vert.	Horiz.
Ro.....	1.36	.36	.25	-.06	.44	.36
Re.....	2.18	1.27	1.19	1.00	.47	.31
Be.....	2.12	1.15	.97	.11	.08	.05
Br.....	2.35	1.50	.53	1.03	-.68	-.53
Average.....	2.01	1.07	.74	.52	.08	.05

two degrees in the same direction as the inducing lines; a vertical line would appear tilted two degrees in the opposite direction. If however the grille is set at 20° the contrast is very much reduced and the consistency of the paired scale-readings is lowered. At 45° the effect is small and variable. This relation between simultaneous contrast and the degree of the inducing tilt is suggestive of that found for successive contrast.

The effect on the horizontal, as shown in the table, is also suggestive of earlier results. When conditions are adequate for contrast applying to the vertical, a similar but usually smaller effect shows itself for the horizontal. Here is further evidence that the two axes function as mutually related spatial standards with a limited degree of independence.

It was discovered after this experiment had been performed that similar results, obtained under similar conditions but in a different connection, have been reported by Krantz.⁴ He has described the phenomenon and published a table and graph of his results which differ from ours only in showing greater amounts of the effect, and a greater variability. His subjects were few, and were mostly children.

One may conclude that the effect of a visual field containing tilted lines on an upright line in that field is one of contrast.

⁴F. Krantz, Experimentell-strukturpsychologische Untersuchungen über die Abhängigkeit der Wahrnehmungswelt vom Persönlichkeitstypus, *Zsch. f. Psychol.*, 1930, Ergbd. 16, 171 ff. Krantz refers to an earlier experiment on this same phenomenon by Hofmann and Bielschowsky but the writer cannot find it from the reference given.

It should be noted that *no subject reported the grille as becoming vertical*, although one did state that he felt as if the lines were his whole world—as if he were in space with them. Presumably these lines underwent adaptation but complete adaptation did not occur. This was true even when the objectively vertical line was excluded from the field.

The contrast phenomenon described is related to certain phenomena described by Koffka⁶ in which the principal lines of the visual field, although tilted from the gravitational vertical, may apparently *become* phenomenally vertical and horizontal under certain circumstances, that is to say, may determine the spatial framework. Obviously, however, our phenomenon is not the same thing since the grille did not dictate the subject's spatial framework. Reference will be made to this problem later.

II. THE RESTRICTION OF THE AFTER-EFFECT TO A PARTICULAR LOCUS WITHIN THE VISUAL FIELD

It will be remembered that the adaptation was first investigated with a tilted line drawn on a visible rectangle of cardboard, the latter seen in a stable upright visual environment. A vertical line in the same region of the field as had been occupied by the adaptation-line appeared tipped, but other vertical and horizontal lines in the field did not seem to be affected and certainly the visual world as a whole did not appear to be tilted. The subject's postural equilibrium was not modified so far as could be discovered. In subsequent experiments all vision of the upright environment surrounding the stimulus-line was excluded, but there was no noticeable change in the phenomenon. When, having inspected a tilted line under these circumstances, the subject took his head away from the cone restricting his vision and looked about the room there was no apparent tendency for the room as a whole to appear tilted.

These observations pointed to a relatively localized occurrence of the adaptation and the negative after-effect rather than a generalized one applying to the entire visual

⁶ K. Koffka, *Principles of Gestalt Psychology*, Harcourt Brace, 1935, Ch. 6.

environment. A systematic set of observations was required on this point, however, and so the following experiment was performed. A 15 cm tilted line was drawn inside a 25 cm square of cardboard having its edges outlined in black, and the latter was pivoted to a 56 cm square cardboard screen. The line was thus 'framed' by both the adjustable 25 cm square and the 56 cm square. This was the adaptation-figure. A second device of this sort was made, different only in that the 15 cm line was drawn vertical. This was the test-figure (Fig. 1, I). The two figures were exposed successively upon

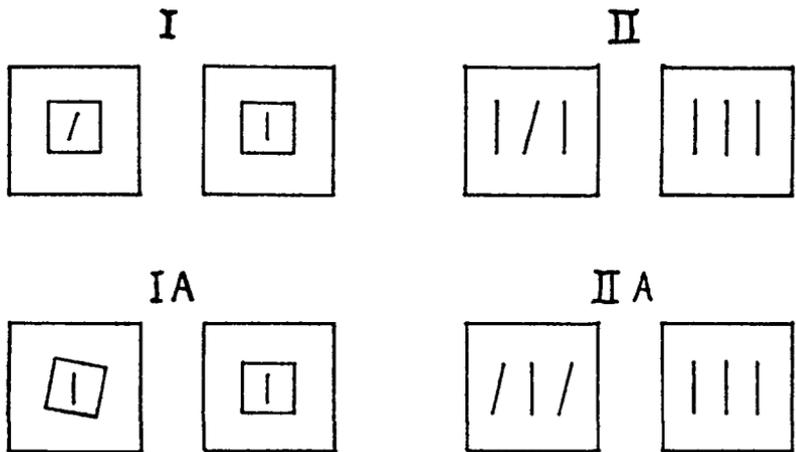


FIG. 1. The adaptation and test-figures used in this experiment. (In each case the figure on the left was looked at for four minutes and then the appearance of the figure on the right was reported.)

a large rectangular screen set in the middle of one wall of a room at a fixation distance of 46 cm. The subjects, after first assuring themselves that the test-line appeared vertical and in alignment with its frame, fixated the midpoint of the tilted line for 4 min, and then closed their eyes for 1 sec while the adaptation-figure was removed and the test-figure beneath it disclosed. They opened their eyes, fixated the objectively vertical line, and reported the appearance of the field. In general, the line showed a negative tilt and the square frame around it appeared normally oriented. The square could be rotated slightly until the line seemed vertical (1° - 2°) but then

the square appeared tilted; if the square was returned to an upright position then the line looked tilted. In short the relationship between the line and the frame had been altered. On a few occasions an observer stated that the square itself looked very slightly tilted in a negative direction, but not as much as the line; the square and the line could still not be put into alignment with one another. No subject, however, reported that the larger square (56 cm) was even slightly tilted, nor were the more peripheral lines affected in any way.

Even more striking results were obtained when the adaptation-figure was arranged so that the square was tilted but the line was vertical (Fig. 1, *IA*). The subjects fixated the midpoint of the line, as before. During adaptation, some degree of simultaneous contrast on the line was usually reported, that is, the line seemed tilted in the opposite direction from the square, and this contrasting tilt was sometimes reported to increase in amount during the 4 minute period along with a decrease in the apparent tilt of the square. When the subject subsequently fixated the midpoint of the test-figure, the square frame appeared very definitely tilted in the opposite direction. So long as fixation was maintained the square continued to look tilted, but if the eyes left the mid point of the line and moved along the sides of the square it appeared normally oriented. The effect was extraordinary—a square visibly tilted at one instant but upright if one looked at the sides to make sure. The orientation of the fixated line within the square in these circumstances was reported to be approximately vertical by some subjects and by others to be tilted in a direction opposite to the negative tilt of the square (clockwise in the diagram of Fig. 1). The latter effect could be accounted for in more than one way; possibly it is simultaneous contrast induced by the apparent tilt of the square.⁶

The two experiments described were now varied by drawing the fixation-line between two lines of equal length instead of within a square (Fig. 1, *II* and *IIA*). The same procedure was used. In *II* the negative after-effect appeared on the

⁶ It may be significant that the analogous simultaneous contrast obtained when one employs a colored negative after-image is very vivid. The induced complementary color is usually as saturated as the color of the negative after-image itself.

middle line when it was fixated, but either not at all or to a very slight degree on the outer lines. If fixation was moved from one line to another, the fixated line showed tilt and the others appeared approximately vertical. In *IIA* the negative after-effect appeared on the two outer lines but the middle line seemed if anything tilted in the opposite direction. The results are, in short, quite analogous to the previous ones.

The results of these experiments were based on the reports of four subjects each of whom observed in a part of the series, and two more subjects who went through the entire series of observations in a balanced order. Both horizontal and vertical after-effects were tested with each variation, although for simplicity the results have been described in terms of the vertical effect only. The results for the horizontal were if anything, even more clear-cut than those for the vertical. Observations were made with a low illumination in order to reduce after-images of the fixated line.

It may safely be concluded that irradiation or spread of the negative after-effect in the visual field, while probably present to some degree, is at least limited in its extent. The normal uprightness of objects in the visual field as a whole tends strongly to be maintained even in the face of a distortion of this orientation produced in one region of the field. Adaptation and after-effect tended to occur in our experiments within a local and partial frame of reference. Strictly speaking, one may not think of this localization of the after-effect as *areal*, like that of after-images, since a line has no area. The observation made at the beginning of the first report that a negative after-effect seen on a line at one fixation distance diminishes or even disappears when the head is moved to a greater or lesser fixation distance supports this proposition. It would probably be more accurate to say that the foregoing experiments indicate that the vertical-horizontal frame of reference, which normally permeates the whole visual field, may be locally modified in the particular way which the adaptation-figure dictates, but not in any other way. The partial independence from one another of the vertical and

the horizontal axes themselves which was described in Parts III and IV of the first report is in line with this interpretation.

The argument might be advanced that the adaptation-figures of I and II in Fig. 1 were of such a sort as to *prevent* the tilt-adaptation from 'spreading' over the whole visual field. The upright square enclosing the 15 cm tilted line might in some way keep the effect localized in a way which would not occur were the square removed from the field. This possibility did not seem very likely in view of the reported normal appearance of the room after earlier experiments with the line in a restricted circular field. But in order to meet it, a single 15 cm tilted line was substituted for the adaptation figures of I and II. The test-figures were unchanged. The after-effect still showed itself clearly on the fixated line but minimally or not at all on outlying parts of the figure.

Transfer from One Eye to the Other.—The negative after-effects of perceived movement and of linear curvature appear in the corresponding area of the field of the other eye when only one eye has been stimulated; the negative after-image of color or brightness, on the other hand, is specific to the stimulated eye.⁷ A number of tests made with three subjects, employing the tilt-apparatus described in earlier experiments and an eye-patch which could be shifted from one eye to the other, indicated that the tilt-effect does transfer to the corresponding region of the unstimulated eye. As compared with a control series which measured the after-effect in the stimulated eye alone, the transferred effect amounted to 57 percent, 83 percent, and 65 percent for the three subjects tested. If one supposes that different types of perception may depend on different neurological levels of the visual system, then orientation is a higher (less peripheral) process than color and brightness.

It may be mentioned that the after-effects obtained in the control series where only one eye was used did not differ from those of previous experiments where both eyes were used.

⁷ J. J. Gibson, Adaptation, after-effect and contrast in the perception of curved lines, this JOURNAL, 1933, 16, 25 ff.

DISCUSSION

M. D. Vernon⁸ reported in 1934 an experiment which took its origin from the fact that a bent line behaves like a curved line in that, after fixating the bend, a substituted straight line looks bent the other way.⁹ She believed that the explanation was to be found in a tendency for each of the arms of the bent line independently to straighten up and become vertical rather than a tendency for the whole line to become rectilinear. The simplest test of this hypothesis would have been to see if the adaptation and after-effect with respect to rectilinearity still occurred when the bent line (and the subsequently seen straight line) were inclined 45° from the vertical. The tendency of the arms of the bent line toward vertical or horizontal is here in opposition to the tendency of the whole line to become rectilinear. The writer has frequently repeated this experiment; the after-effect of either a bent or curved line shows up independently of the orientation of the line. The only requirement is that the adaptation line and the test line shall be in the same orientation. The after-effect of a linear curve or bend is therefore separable from the after-effect of a linear tilt.

Vernon, however, went on to verify the tendency for an inclined line to become vertical. Her subjects looked with one eye for 10 minutes at a line (or a set of parallel lines) tilted 10° from the vertical in a restricted circular field. Before and immediately after this period the line-figure was adjusted to the vertical position. The differences between these two adjustments were consistently in the expected direction; six subjects yielded varying amounts of after-effect which averaged about 2.5° . Our results are perfectly in agreement with hers. She obtained a somewhat higher average amount of effect, but differences in procedure and the fact of individual differences among subjects are probably adequate to account for any discrepancy.

⁸ M. D. Vernon, The perception of inclined lines, *Brit. J. Psychol.*, 1934, 25, 186-196.

⁹ J. J. Gibson, *op. cit.*, 18 ff. The phenomenon has also been noticed by F. H. Verhoeff, A theory of binocular perspective, *Am. J. Physiol. Opt.*, 1925, 6, 436.

Vernon did not explore any of the aspects of the phenomenon with which the present report and the previous one have been concerned. She apparently assumed that the adaptation and after-effect could be obtained only in a restricted circular field where the line itself was the only visible direction. Her subjects looked through a circular hole in a screen, using one eye only. She explained the phenomenon as a shift of the general spatial level or framework,¹⁰ and this explanation requires consideration. Koffka has pointed out that phenomenal space serves not only as a ground against which objects are seen but as a frame of reference for their orientation and location. Lines and objects in the frontal plane are seen as upright or tilted by virtue of the horizontal-vertical framework. According to this theory, however, not only does the framework provide a reference base for the position of visual lines and objects but it is itself determined by the main lines of the visual field—the principal visible directions. The horizon-line would be such a principal direction. These main lines of the field, even if by chance or by experiment not gravitationally vertical and horizontal, will become so phenomenally because they determine the framework. Experimental evidence for this theory comes from Wertheimer.¹¹ He performed an experiment in which the subject looked through a tube into a mirror-surface so tilted as to present to his vision an image of the room inclined at about 45° from the objective vertical. After an interval the room was reported to become normal in appearance; it was upright because the main lines had become the subject's framework.

Vernon adopts this theory as an explanation of the tilt-effect. She supposes that in her experiment the tilted line provided the subject's framework. She adds that "this spatial framework tended to appear as vertical as possible, *i.e.* to move towards the vertical position."¹² As stated, this explanation is self-contradictory for if the line was vertical

¹⁰ K. Koffka, Perception, an introduction to Gestalt theory, *Psychol. Bull.*, 1922, 19, 531, and *Principles of Gestalt Psychology*, Ch. 6.

¹¹ M. Wertheimer, Experimentelle Studien über das Sehen von Bewegung, *Zsch. f. Psychol.*, 1912, 61, 257-262.

¹² M. D. Vernon, *op. cit.*, 190.

(i.e. provided the framework) it could not tend "to appear as vertical as possible." As a matter of fact, the subjects in our experiments did not report that the line ever looked unmistakably vertical and remained so. They did report that it fluctuated and that it became less tilted. It is possible that this criticism is mainly a verbal one. Just what Vernon meant to imply is not clear.

But in any event, the theory of a labile spatial framework shifting in accordance with the dominant visible directions is not really applicable to the phenomenon which we have investigated. In the first place, the adaptation is partial rather than complete. In the second place, the effect is non-existent at 45° , and hence is different from the phenomenon which Wertheimer observed. Both of these facts were established in the first paper. Finally, as we have just seen, the adaptation with after-effect can occur in a localized part of an otherwise stable visual field. The spatial framework *as a whole* is not affected.

The evidence obtained in these experiments seems to point toward a somewhat different interpretation. The effect behaves like a partial and local adaptation process akin in many respects to sensory adaptation. Color and brightness, linear shape, movement, skin temperature, and probably other such dimensions of human perception are parallel in this respect to linear orientation. A theory of the phenomenon of tilt-adaptation and after-effect should, if possible, be in such terms as will include these analogous phenomena. An attempt at a general theory of this sort requires a separate paper. Only an indication will be given of the concepts which could be employed and their application to linear orientation.

The vertical and horizontal axes, as we have seen, are implicit in visual perception. They can be produced without visual cues, and presumably their *ultimate* determinants are postural. In the frontal visual plane lines have the quality of direction with respect to these axes, and only with respect to them can directions be discriminated. A tilted line is one which deviates from, say, the vertical in one of two regular ways, to the right or to the left. A vertical line on the other

hand is simply one which is not tilted in either of these ways. 'Vertical' and 'tilted' are definable only in terms of one another. They may be said to constitute a single sensory continuum. The term 'sensory' is applied not in its older systematic meaning but only to indicate a simple character of perception. A number of reasons could be given for terming both linear direction and linear shape sensory but their relative simplicity is sufficient reason for the present discussion. Correlative with the vertical-tilted continuum there is of course a quantifiable stimulus continuum, based on the gravitational vertical and horizontal and measurable in angular degrees.

Now this sensory continuum, in common with some others already mentioned and also with a large number of more complex dimensions of experience, consists of a central norm or standard between opposite qualities. The central quality is neutral with respect to the others and is unique. The two opposite qualities become increasingly intensified as they deviate from the norm. The opposition of the two qualities consists in the fact that they cannot coexist in the same object at the same time, and if one attempts to modify the stimulus in both ways at the same time, the neutral quality results.¹⁸ The opposite qualities might be designated as plus and minus, the norm as zero. The series is symmetrical, and it may or may not have specific limits or ends. In the case of linear orientation, there are two such 'opposition series,' related to one another, one for vertical and one for horizontal.

In these general terms tilt-adaptation would be a process in which the normal correspondence between the stimulus-continuum and the sensory series is altered. A prolonged inspection of a tilted line results in a decrease in the apparent tilt. This means that a retinal tilted line now corresponds to a phenomenal less-tilted line. And since, as we have seen, the vertical-tilted series is 'all of a piece' it follows that a retinal vertical line corresponds to a phenomenal oppositely-tilted line. This last is of course the negative after-effect proper. Likewise, a line to be seen as vertical must be tilted

¹⁸ For a discussion of various types of opposition in relation to series or scales, see C. K. Ogden, *Opposition*, *Psyche Miniatures*, Gen. Series, 1932, No. 41.

somewhat with the same quality as the adaptation-line.¹⁴ The relationships are represented in Fig. 2.

There is a corollary of this theory. The question of whether the tilted line has tended to become vertical or whether the subjective vertical has tended to become the perceived line is not only indeterminate but is a false problem. One cannot simply say that during a prolonged perception, the tilt quality of a line is shifted toward the norm of its series. That is true, but it would be just as true to say that instead the norm is shifted toward the perceived quality. The norm and the series are mutually dependent; they are relative to one another and neither the one nor the other is primary. The two statements, therefore, come to the same thing. A better statement than either is that during a prolonged per-

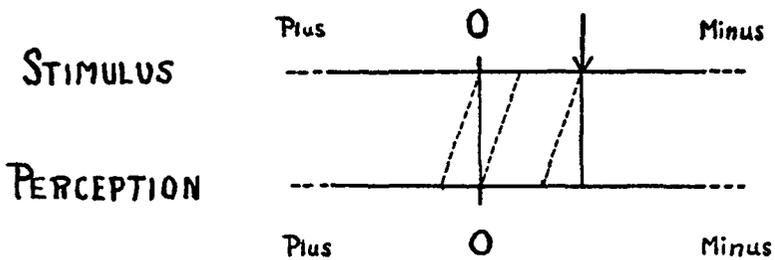


FIG. 2. Diagram of the relations between the stimulus-continuum and the sensory series before and after a period of tilt-adaptation. (The arrow indicates a prolonged stimulus-presentation. The solid lines indicate the correspondence between retinal and seen tilt at the beginning, and the dotted lines at the end, of the adaptation period.)

ception the correspondence between the sensory series and the stimulus series has been altered throughout in such a way as to reduce the discrepancy between the norm and the perception. The actual stimulus is now correlated with a subjective quality nearer its norm, and this norm is now correlated with a stimulus-value closer to that of the actual stimulus. Presumably when the stimulus-line is removed from the field the process by which these correspondences were changed is now reversed and there is a return to the usual relationship. This process of adjustment and readjustment of the retinal-sensory

¹⁴ Cf. J. J. Gibson, *op. cit.*, p. 7 and Fig. 2.

correspondence, it should be remembered, is partial rather than complete. In the first place it tends to be limited to the region of the visual field occupied by the non-normal perception. And in the second place the discrepancy between the norm and the perception does not disappear but only decreases.

This tendency of a perceptual quality toward the norm of its series should not be identified with the tendency of perceived and remembered forms toward types, centers, or good configurations. Studies of perception by the method of immediate or delayed reproduction or by the method of recognition, usually with reduced stimulus-conditions, have to do with the determinants of perceptual 'errors' or memory-changes; the 'method of prolonged perception' has to do with a change of the retinal-phenomenal correspondence itself. A study of the perceptual orientation of forms by the first method has been made by the writer.¹⁵ The similarity of the results in the two experiments should not disguise the difference in the problem investigated.

The theory has been proposed that successive contrast is a process which involves a sensory 'opposition' series. The prolonged perception of a particular quality not the norm of its series results in a gradual shift of the serial correspondence between stimulus and quality of such a sort as to reduce the abnormality of the particular quality. Simultaneous contrast, such as was observed in the first experiment reported, might be described in the same terms. We can suppose that the perception of a non-normal quality over a large area of the visual field has an immediate effect upon the quality of an enclosed region of differing stimulus value such that the quality in this region is shifted from its usual stimulus base in a direction opposite to the surrounding quality. There is a difference between these two formulations, however. The last one is in no sense explanatory of the contrast-effect as the first one is of the negative after-effect. Although the simultaneous contrast phenomenon as it was observed in this experiment probably also involves the notion of a sensory opposition series and bears an intriguing resemblance to the

¹⁵ M. Radner and J. J. Gibson, Orientation in visual perception; the perception of tip-character in forms, *Psychol. Monog.*, 1935, 46, No. 210, 48-65.

after-effect phenomenon, it is far from being the same thing and requires some hypothesis of its own.

It should be pointed out in conclusion that this experiment has dealt with linear orientation under the special conditions of a frontal plane stimulus-line and an upright posture of the head. Linear orientation in the third dimension has been set aside for separate experimental treatment, although the writer believes that it too manifests the same general phenomena. Likewise the fact of a 'constancy' of linear direction—its strong tendency to remain phenomenally unchanged when the head and retinae are tilted and the special case illustrated by the Aubert phenomenon—has been left out of account. In our experiment an objectively vertical line was always correlated with an objectively upright retinal image. The stimulus-continuum which has been referred to should therefore be understood in every case as the stimulus-continuum-with-the-head-upright. Ultimately these experiments should be extended to include conditions of abnormal posture.

SUMMARY

1. Linear directions in the visual frontal plane are perceived by reference to the norms of vertical and horizontal which remain stable and precise in an otherwise homogeneous visual field.

2. A perceptual tilt which lasts over a period of time results in a reduction of the apparent tilt and a subsequent negative effect on an ordinarily normal stimulus-line. The adaptation and after-effect, so-called, have been interpreted as a partial adjustment with subsequent readjustment of the retinal-sensory correspondence.

3. The vertical and horizontal norms and their two respective series of tilt-qualities may be said to constitute a single system and yet to operate in partial independence, since an after-effect on one norm transfers only in part to the other norm.

4. The effect occurs in that region of the field of vision where a tilt-perception has been maintained; the field as a whole remains unaffected.

5. Simultaneous as well as successive contrast is operative.
6. Linear direction is similar to linear curvature or shape with respect to a number of common functional characteristics.
7. The hypothesis is suggested that a number of types of perceptual experience are subject to adaptation with negative after-effect, namely those which fall into what has been called an opposition series.

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