

THE PREVALENCE OF SPATIAL CONTRAST IN VISUAL PERCEPTION.

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The aim of the investigation.

Details regarding the method employed.

*Discussion of the results; complexity of the factors involved in
their interpretation.*

Special features of the determinations.

It is the object of this paper to present observations regarding the modifications in spatial perception which are introduced when a line in the visual field, whose length is being estimated, is accompanied by another line parallel to it and of varying length. The problem is of interest on two grounds: it presents one of the simplest cases in which contrast can appear, and it comes into close relation with phenomena of ordinary experience in which the influence of contrast is usually supposed to be quite evident. An account was given in an earlier paper¹ of experiments which were directed in part to the study of this topic. The results obtained on that occasion were sufficiently definite, and appeared to render superfluous the employment of contrast as an explanatory condition. Since, however, the data in that investigation were supplied by two subjects, who at the same time were conducting the experiments, it appeared desirable to secure observations from a larger number of subjects, who also should be ignorant of the special significance of their work at the time when the determinations were being made.

Observations fulfilling these conditions were obtained from members of the class of Psychology in the University of Edinburgh in the course of work carried out during the Summer Term, 1913. From those who took part in the work forty were selected, twenty of these being men and twenty women; the ground of choice lying in

¹ This *Journal*, 1907, II. 196.

318 *Prevalence of Spatial Contrast in Visual Perception*

the satisfactory character of the work which was done in following out the procedure indicated to the class. It is the results obtained from these subjects which are submitted to examination in the following pages. By the time the determinations were made a fair amount of training in other lines of experimental work had already been gained by the subjects, and the work on contrast followed immediately on that which had been given to the study of the Müller-Lyer illusions in visual space perception. It may be mentioned that the measurements involved in working out the results which are to be dealt with in this paper were carried out by the author¹. In its general character the method of reproduction, employed on the present occasion, was the same as that of the earlier investigation to which reference has already been made. The following are the special features of the procedure.

The material which was used in the experiments consisted in the first place of cardboard sheets of uniform size on which were printed the lines which presented the relation of contrast and connected features. The size of these sheets, which may be termed conveniently 'pattern sheets,' was 12 by 8 inches; the breadth of the lines, which was the same throughout, was slightly over $\frac{1}{8}$ in. On all the sheets there appeared a line 4 in. in length, which we shall term the 'constant line.' On one set of sheets this constant line appeared without any accompanying line; on the other sets it was accompanied by another line lying parallel to it at a distance of half an inch. In the first or 'normal' case we have the means of securing data regarding normal estimation; in the other 'special' cases the influence of the accompanying line may be studied. The lengths of the accompanying lines in the special cases, seven in number, were the following:—1, 2, 3, 4, 5, 6 and 8 in. The single line in the normal case and the pair of lines in the other cases lay parallel to and midway between the two longer sides of the pattern sheet. The constant line was placed in all cases so as to have one end distant 2 in. from one of the short edges of the sheet; where there was an accompanying line it had one end placed similarly with respect to the same edge. There were prepared in addition sheets of ruled foolscap paper, on which was printed a vertical marginal line distant approximately $1\frac{1}{4}$ in. from one side of the sheet—the side which was to lie towards the left hand of the subject.

¹ A report presenting some of these results was included in a paper on "Contrast as a factor in psychological explanation" which was read in the Psychological Subsection at the meeting of the British Association in 1913.

Following the directions given at appropriate points in the course of the work, each subject placed on the left hand a pattern sheet with its longer edges parallel to the edge of the table at which he sat, and on his right hand (in contact with the pattern sheet) a sheet of the prepared foolscap paper. In carrying out each determination the subject looked at the constant line as long as he wished; then without looking back he made on a line of the sheet lying on his right a mark in ink at a point such that the distance between it and the intersection of the horizontal and vertical lines on the left seemed equal to the length of the constant line. As soon as the mark was made, and without any attempt being made to compare the reproduced and presented distances, the sheet containing the marked line was moved upwards under another covering sheet, a fresh surface being thus exposed for the next determination. The horizontal line which was being marked lay approximately at the same level as the line whose length was being reproduced; the covering sheet was kept in the same position throughout, and by means of an additional underlying sheet the total area of paper exposed remained constant. Eight determinations were made in the normal case, while six determinations were made in each of the seven special cases. A certain variation was introduced by arranging that one division of the subjects, containing ten men and ten women, should have the pattern sheet so placed that the constant line was the upper one of the two parallel lines, while the second, containing the same proportion of subjects, had the lines presented in the opposite position. It may be pointed out that this arrangement permitted one, without drawing special attention to the character of the constant line, to give appropriate directions for the work by referring to the reproduction of the 'upper' or 'lower' line. An additional variation was introduced by making the order of the determinations different in the two divisions indicated above. Referring to the normal case by the letter *a*, and to the special cases, taken in the order of increasing magnitude of the accompanying lines, by the letters *b* to *h*, we may state the difference succinctly as follows. In Division I there were first two consecutive determinations for each case in the order *a* to *h*; next two for each case (except *a* where 4 were made) in the order *e* to *h*, then *a* to *d*; lastly two for each case in the order *h* to *a*. In Division II the order was first *h* to *a*; next *d* to *a*, then *h* to *e*; lastly *a* to *h*. It might fairly be expected that these changes, while heightening, perhaps, the variability of the reproductive process, would tend to neutralise the effect of irrelevant conditions and furnish a clearer

320 *Prevalence of Spatial Contrast in Visual Perception*

insight into those relations of the phenomena in which we are now interested.

In Table I are presented the results for the divisions taken separately, and also for the subjects taken together for the purpose of forming a general average (Gen. Av.). The various cases are indicated at the head of each of the vertical columns, not merely by the letters already employed, but also by numbers giving the length in inches of the accompanying line. The length of the reproduced lines has been measured in millimetres and fractions of this unit; the length of the line which was to be reproduced was approximately 101.4 mm. in length¹. With the aim of throwing into relief the two sets of results which may be compared with those where contrast might make its appearance, the *a*-0 and *e*-4 cases have been distinguished by doubled vertical lines. It may be remarked with respect to the general averages that each of the numerical values is based on 240 measurements, with the exception of that for the normal case (*a*-0), where the total is 320.

TABLE I.

	<i>a</i> -0	<i>b</i> -1	<i>c</i> -2	<i>d</i> -3	<i>e</i> -4	<i>f</i> -5	<i>g</i> -6	<i>h</i> -8
Div. I	94.1	95.4	94.7	94.4	93.9	94.1	93.4	92.9
Div. II	94.7	95.5	94.9	94.6	94.8	95.3	95.1	94.9
Gen. Av.....	94.4	95.4	94.8	94.5	94.4	94.7	94.3	93.9

If we consider first the general averages we seem to find evidence of the operation of contrast in the two extreme cases, *b*-1 and *h*-8; viz. an increase in the estimated length of the constant line when the accompanying line is shorter than it, and a decrease when the accompanying line is longer. The same is true of the results for the divisions taken separately with the exception of the case *h*-8 in the second division. Taking the other cases, where the difference between the two parallel lines, though not so great, is yet quite obvious, we find on the other hand that there is little or no evidence of modification due to contrast either in the general, or in the more detailed averages. While the values in the case of normal estimation, *a*-0, form the chief basis in the examination of the evidence for contrast, it seems fair to take into consideration also the values in the case *e*-4, which are seen both in

¹ It should be noted that, had the constant line as printed been exactly 4 in. in length, it would have measured 101.6 mm. approximately. The various accompanying lines as printed were similarly, with slight variations, below the standard length.

this table and in Table II to correspond with great closeness to those in the case $a-0$.

It will be observed that, of the modifications, or differences, which might be attributed to contrast, the greatest are those presented by the first division in the two extreme cases, viz. an increase of 1.3 mm. in the case $b-1$, and a decrease of 1.2 mm. in the case $h-8$. A basis for estimating the significance of these and other related values has been sought in the calculation of the probable error of the various averages involved in the determination of the differences. This has been carried out for the cases $a-0$, $b-1$ and $h-8$, and in addition for the case $e-4$. The values of the probable error are given below not merely for Div. I, in which the greatest differences are found, but also for Div. II.

$a-0$		$b-1$		$e-4$		$h-8$	
I	II	I	II	I	II	I	II
1.1	1.2	1.2	1.5	1.1	1.2	1.1	1.5

As will be seen, the differences between the normal and the modified estimations in the two extreme cases of the first division ($b-1$ and $h-8$) are greater than the probable errors of each of the averages on which the differences are founded. This fact, however, is of comparatively slight significance. It is more important to consider the relation of each difference to the joint variability of the averages involved in its determination¹. We find then that in no case does the magnitude of the difference approach the sum of the probable errors of the averages on which it is based. It may be suggested that other criteria of variability might be employed, *e.g.* the error of mean square. It may be taken, however, that the use of the probable error is not an unduly severe procedure, and if a more stringent test be desired, a few calculations based on the values presented above will indicate its bearing on the present problem. To the question, then, regarding the significance of the differences which might be attributed to contrast, the answer must be that in view of such a criterion their value is slight, and that they furnish little or no proof of the general prevalence of contrast. Were the effects attributable to contrast shown in a series of differences which though small in magnitude, were continuous and

¹ Cf. Radicke, Wunderlich's *Archiv f. physiol. Heilkunde*, 1858, N.F. II: v. also translation of the New Sydenham Society, 1861, XI.

322 *Prevalence of Spatial Contrast in Visual Perception*

harmonious, it might be urged that some significance should still be attached to them. But the actual series of differences can hardly be said to possess these characteristics in a marked degree.

Reference may be made at this point to the conclusions reached in the earlier investigation of this topic. It was then found that there was a decided and regular tendency on the part of both subjects to increase the length of the reproduced line when the constant line was accompanied by another which was longer than it, but that no distinct modification was apparent—at the most, only a slight tendency towards increase—when the accompanying line was shorter. The results of the present investigation appear to be as completely out of harmony with the principle of confluence which was applied in the interpretation of these earlier data, as with the principle of contrast.

A suggestion has, however, been gained for an interpretation, which will avoid merely negative conclusions, in the analysis of the present data from another point of view. When averages are calculated separately for the groups of men and of women (twenty subjects in each group) the following results are found.

TABLE II.

	<i>a</i> —0	<i>b</i> —1	<i>c</i> —2	<i>d</i> —3	<i>e</i> —4	<i>f</i> —5	<i>g</i> —6	<i>h</i> —8
Men.....	92.5	94.1	93.0	92.2	92.5	92.2	91.5	91.3
Women	96.3	96.7	96.6	96.9	96.2	97.2	97.0	96.5

It is of some interest to notice that in all the cases the average length of the reproduced line is less in the group of men than it is in the group of women. That this feature is not a matter of chance is clear when we consider not merely the persistence, but also the magnitude of the difference in the various cases. As regards the latter point, we find on applying the test already used to the normal case, which we may take as an example, that while the difference between the estimations of men and women amounts to 3.8 mm., the probable error of the men's average is 1.3 and that of the women's average is 1.1, their sum being 2.4.

Passing from the consideration of this feature we note that the group of men presents a series of modifications, which, though not striking in magnitude, are yet fairly uniform and, except in the case *d*—3, are in harmony with the influence of contrast. The group of women, on the other hand, shows a fairly uniform tendency in the

direction of increase, whether the accompanying line be long or short, the magnitude of the increase, however, being less in the cases where the accompanying line is shorter than the constant line. In other words there are indications in the latter group of the operation of confluence.

The suggestion might then be made that while the results do not afford ground for asserting the general or unrestricted prevalence either of contrast, or of confluence, they yet give some indications of their presence. In the circumstances of the present investigation these two conditions are probably in part antagonistic. Their relative effectiveness may reasonably be supposed to vary according to the individuality of each subject, and, further, according to the general tendencies of sex. We have already seen that there is a decided difference between the men and women, who took part in this work, with regard to the determination of the lines. One might say then that while contrast is more prevalent among men, confluence is more prevalent among women. The results of the earlier investigation would fall to be explained by a dominance of confluence in the subjects taking part in that investigation. The question may, however, be raised:—if the determinations of the group of women are to be regarded as dominated by confluence, how does it come that this group presents an increase in the cases *b-1*, *c-2*, *d-3*, instead of the decrease which confluence might be expected to introduce? A fully satisfactory answer to this question cannot be given, but reference may be made to certain points. On the ground of observations regarding the magnifying and diminishing forms of the ordinary Müller-Lyer illusion it may be assumed that confluence is less effective in reducing the apparent length of the longer of two parallel lines than in increasing the length of the shorter. In other words, the condition which is antagonistic to confluence will have more scope in the cases *b-1*, *c-2* and *d-3* than in the other special cases. We may thus, perhaps, look on the increase of the reproduced line in these cases as an indication of the restricted manifestation of contrast¹. It may be that the tendency in the group

¹ It has been assumed above that confluence is operative both in the ordinary Müller-Lyer illusion and in the analogous case where two parallel lines of different length are presented—a case whose relation to the former is seen if we suppose the ends of the parallel lines joined so as to form distinct angles. Cf. this *Journal*, II. 203, 214. Since the modification in the magnifying form of the Müller-Lyer illusion has been proved to be decidedly greater than that in the diminishing form, it has been assumed further that this involves a difference in the effectiveness of confluence in the two forms. Cf. this *Journal*, II. 22. This difference between the two forms may also involve in a measure the antagonism suggested above. Cf. Lewis, this *Journal*, 1909, III. 21.

324 *Prevalence of Spatial Contrast in Visual Perception*

of women towards a relative increase in the length of the reproduced line—or, as we should perhaps say, the tendency on the part of the men towards decrease—has some bearing on the mode in which these tendencies are realised. The results mentioned in the next paragraph may be taken as evidence on this point. Other tendencies, which at present one can only describe as accidental, are doubtless at work also.

An attempt has been made by grouping the subjects in various ways to reach conclusions on other points of interest. Such attempts, however, are apt to meet with difficulties owing to the selection involved in the grouping. One may, for example, choose from the subjects those who show a special tendency in some section of the cases. In doing this however we are in fact at the same time making a selection of instances where the reproduction of the lines in the other cases is modified by the opposed tendency. The analysis may thus furnish us with little that is instructive. This may be illustrated by considering the result of selecting those subjects who show a definite tendency to increase the length of the reproduced line in the special cases *f*-5, *g*-6, *h*-8. With this in view a group was formed of the ten subjects (4 men, 6 women) who made the reproduced line in two at least of these special cases greater than that in either of the cases *a*-0, *e*-4. The following are the averages for this group:

<i>a</i> -0	<i>b</i> -1	<i>c</i> -2	<i>d</i> -3	<i>e</i> -4	<i>f</i> -5	<i>g</i> -6	<i>h</i> -8
93.0	94.6	94.2	94.4	93.4	95.6	95.8	93.8

It will be noted that the selection has not left the averages for *a*-0 and *e*-4 untouched; they are distinctly less than those of the general average in Table I. In addition the values in *b*-1 and *c*-2 show a corresponding decrease. It may be observed also that we find evidence in the group thus selected of the tendency, already found to be characteristic of the group of women, towards an increase in the reproduced line (when compared with that in the case *a*-0) when the accompanying line is less as well as when it is greater than the normal line.

The characteristic reproductive tendency of the individual subject manifests itself with remarkable uniformity in the various cases and forms one of the dominant facts. This feature is illustrated clearly by the results contained in the following table. The upper and lower series of values present, respectively, the averages for each of two

groups of five individuals:—(A) those among the forty subjects whose reproductions of the line in the $a-0$ case stand highest, and (B) those whose reproductions are lowest. We may note how persistently the tendency towards increase or decrease exhibited in the normal case is maintained throughout the special cases.

TABLE III.

	$a-0$	$b-1$	$c-2$	$d-3$	$e-4$	$f-5$	$g-6$	$h-8$
A.....	108.0	109.2	107.3	109.0	106.1	106.0	106.8	107.9
B.....	80.9	81.0	80.3	80.2	81.8	82.5	81.1	81.1

It will be observed that while there is an increase in the averages of the A group (as compared with the normal line of 101.4 mm.) the corresponding decrease in the B group is much greater, being on the whole more than twice as great. We have here before us the expression in another form of the general tendency towards making the length of the reproduced line less than that of the normal line—a tendency which, as has been seen in Table II, holds both for men and women, though in different degrees.

The mean variation has been determined for each individual in the cases $a-0$ and $h-8$; the average of these mean variations has then been calculated for the groups of men and women taken separately. It has been found that in these cases the values for the men are, respectively, 3.0 and 2.7, while those for the women are 3.3 and 2.5. It would thus appear that, so far as the present investigation is concerned, there is less variability in the reproduction of the modified than in that of the unmodified line, and, further, that the work of the men is somewhat less variable than that of the women.

SUMMARY.

1. There is little or no evidence in the general results of this investigation dealing with parallel lines that contrast is distinctly and generally operative in modifying the apparent length of a line. On the other hand there are certain facts which may be regarded as suggesting that it is present together with other conditions, such as confluence, which in certain situations neutralise its influence but in others permit it to appear.

326 *Prevalence of Spatial Contrast in Visual Perception*

2. When the subjects are divided into groups of men and women it is found that the results of the former group are more readily interpreted in accordance with contrast, and those of the latter in accordance with confluence.

3. It is found that, while the average length of the reproduced is less than that of the presented line with both men and women, the tendency towards decrease is markedly greater in the group of men.

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