EFFECT OF INSTRUCTIONAL SET ON DEGREE OF SIMULTANEOUS BRIGHTNESS CONTRAST

by

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A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Psychology

Greensboro
August, 1966

Approved by

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PARRISH, MICHAEL: Effect of Instructional Set on Degree of Simultaneous Brightness Contrast. (1966) Directed by: Dr. Kendon Smith.

Explanations of simultaneous brightness contrast consistent with traditional nativistic and empiricistic points of view have been presented. Evidence relevant to these views has been cited from experiments employing the techniques of electrophysiology of the retina and from experiments based on psychophysical methods. Inasmuch as the evidence is not conclusive and the theoretical issues remain controversial, this experiment was designed in an attempt to aid in clarification of these issues.

A nativistic, or peripheral, explanation of simultaneous brightness contrast is based on a visual response mechanism in the retina; and an empiricistic, or central, explanation is based on past experience and learning; therefore, the experimental question here was whether instructions given the S would effect the degree of simultaneous brightness contrast. These instructions were designed to instill a "whole-perceiving attitude," on one hand, and an "analytical attitude," on the other.

Twenty Ss, 12 female and 8 male, were selected from graduate students and upperclassmen majoring in psychology at the University. They were randomly assigned to two groups, one group receiving "whole-perceiving" instructions, and the other group receiving "analytical" instructions prior to observation of the simultaneous brightness contrast situation. Each S had four experimental sessions, with no more than one session falling on any single day.

Statistical analysis revealed a significant difference between the results of the two conditions of observation of simultaneous brightness contrast. A significant

enhancement of reported contrast was associated with instructions to adopt a "whole-perceiving" attitude rather than an "analytical" attitude. These results suggest that simultaneous brightness contrast can be best considered within a traditional empiricistic framework.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation and intellectual indebtedness to his thesis advisor, Dr. Kendon Smith, without whose guidance and enthusiasm this paper would not have come about.

I am indebted to the other members of the committee, especially Dr. E. E. McDowell III, who assisted, along with Dr. Smith, by rating subject responses.

I am also grateful to Dr. Donald H. Ford ofThe Pennsylvania State University who made helpful suggestions as to procedure.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

> .....what we have to do now is to investigate the mutual influence of different luminosities and colours appearing together in the visual field side by side with each other.
>
> The result of such a juxtaposition usually is that each portion of the visual field next a brighter one looks darker, and vice versa; and a colour alongside another colour resembles more or less the complementary colour of the latter. The opposition thus manifested is implied in the term contrast (Helmholtz, 1866, Vol. II, pp. 264-265).

The contrast phenomena thus described by Helmholtz have become well known to psychologists. At the same time, their explanation has become a perennial problem. Attempts to explain them have been made by advocates of both the empiricistic and the nativistic position. Historically, the definitive statements for the two points of view have been made by Helmholtz and Hering.

The empiricistic position on perception in general was succinctly stated by Helmholtz as follows:

> Consequently, it may often be rather hard to say how much of our apperceptions (<u>Anschauungen</u>) as derived by the sense of sight is due directly to sensation, and how much of them, on the other hand,

is due to experience and training. The main point of controversy between various investigators in this territory is connected also with this difficulty. Some are disposed to concede to the influence of experience as much scope as possible, and to derive from it especially all notion of space. This view may be called the empirical theory (empiristische Theorie) (Helmholtz, 1866, Vol. III, p. 10).

The principle that perception is based on experience is applied to contrast, in particular, in the following statement:

> In the author's opinion the phenomena belonging here are of an entirely different kind from those heretofore considered. In general, they may be characterized as cases in which it is not possible to make an exact estimate of the reacting colour by comparing it with other or inducing colours. Under such circumstances we are disposed to regard those differences which are distinctly and positively perceived in the observation as being greater than those which either stand out indistinctly or must be estimated by the aid of memory. Doubtless this is a general law in all our perceptions (Helmholtz, 1866, Vol. II, p. 270).

This statement that contrast is due to an "error of judgment" on the part of the perceiver indicates that learning and past experience are to be regarded as the major factors in the perception of this illusion.

Hering's nativistic approach to perception contrasts sharply with Helmholtz's empiricism. Hurvich and Jameson have summed it up in the introduction to their translation of Hering's Outlines Of a Theory Of The Light Sense. Discussing simultaneous contrast especially, they comment:

> What do such phenomena signify? To some they signified "illusions of judgment." This was true of many of Hering's contemporaries for whom judgmental or interpretive processes were presumably required to transform the raw material or elements of sensory experience into meaningful perceptions. To Hering, on the other hand, these contrast phenomena meant that the visual system could not be regarded as a mosaic of independent response elements that corresponds to a simple mosaic of stimulus elements. The visual system must, he reasoned, be conceptualized in terms of tissues of interrelated, rather than independent, elements. Thus, the activity in each element must depend not only on its own external stimulus in relation to its momentary internal state, but also on the activities in the neighboring and related elements of the integrated tissue (Hurvich and Jameson, 1964, p. viii).

Hering considered "change in local brightness with unchanged local stimulation" (Hurvich and Jameson, 1964, p. xxiii) a reflection of a property of the physiological response mechanism of the retina. He called this property "reciprocal opponent induction" or "interaction," and he made it the basis for his nativistic, or peripheral, statements about perception (Hurvich and Jameson, 1964, p. xxiii). Thus, in Hering's own words:

> *What is decisive for the effect of an element of the visual substance on its surround is the amount of the difference between its simultaneous dissimilation and assimilation.* Each element whose dissimilation is greater than its assimilation ($D > A$) induces in its surround a positive increment to the assimilation and negative increment to the dissimilation that would otherwise take place in the surround: each element whose assimilation is greater than its simultaneous dissimilation ($D < A$) induces in its surround a positive increment to the dissimilation otherwise brought about here, and a negative increment to the assimilation (Hering, 1920, p. 173).

Research devoted to the explanation of simultaneous brightness contrast has been largely shaped by these two traditional points of view.

Recent evidence favorable to Hering's opponent-induction theory has stemmed from studies of the electrophysiology of the retina. The illumination of a given retinal region, in certain species, results in the inhibition of activity in surrounding regions, and this fact is considered evidence of a retinal basis for contrast. Hartline (1949), in his classical work with *Limulus*, found that the frequency of discharge in an optic-nerve fiber after stimulation of an appropriate receptor unit could be reduced by stimulation of receptor units in adjacent areas. Further study of lateral inhibition in the *Limulus* eye by Ratliff and Hartline (1959) led to a retinal explanation of the perceptual sharpening of borders between neighboring light and dark areas; due to aberration in the eye, such borders would be expected to be unclear and hazy. Each sensory cell is considered to exert an inhibitory effect on every other cell, and each is thus inhibited by every other active cell. The area of the retina stimulated by the lighter portion of a contrast field is not inhibited to as great an extent as the area stimulated by the darker portion; the light area is not receiving inhibitory impulses from the dark area, but the dark area is receiving many such impulses from the light. This interaction then increases the contrast and sharpens the border between the two areas.

Diamond (1960) has developed a related theory of depression and enhancement in brightness. It is also based primarily on evidence of inhibition from work done with Limulus, although it makes some use of mutually exclusive "on" and "off" centers in the retina of the cat, whose existence indicates the possible occurrence of lateral excitation and inhibition (Granit, 1955, p. 69). Kuffler (1952) has also reported "on" and "off" antagonistic centers in the retina of the cat.

The neurophysiological evidence is undoubtedly important. Much of it, however, arises from the study of Limulus. As Graham (1965, p. 246) has recently remarked, models developed on the basis of Limulus are interesting; but the mammalian visual system is more complex than that of Limulus, and the real value of such models is open to question.

The neurophysiological data have been recently supplemented by the results of psychophysical investigations. In 1955, Heinemann performed such a study, in which a test field was encircled by an inducing field, and the luminance of the inducing field was varied. His results revealed that, in a general way, an increase in the luminance of the inducing field resulted in a decrease in the brightness of the test field. Heinemann's findings have been verified in detail by Torrii and Uremura (1965).

These results are usually considered favorable to a retinal-process interpretation of contrast. The general trend of the curves is actually consistent with the position taken by both Hering and Helmholtz. Inspection of Fig. 1 reveals, however, an important detail in the data: there is an initial rise in apparent brightness of the test field as a function of inducing fields of luminance. This rise in apparent brightness persists until the luminance of the inducing field and that of the test field approach equality. At this point the apparent brightness of the test field begins to decline. A retinal interpretation would predict a falling-off effect, but not the enhancement effect that is present. Inasmuch as the effect is in fact present, Heinemann states:

> Nonetheless, it seems more probable that the enhancement effect also reflects some interaction effect within the visual system. Both facilitation and inhibition are known to occur within the visual system but the present experiments provide no way of choosing among many possible mechansims [sic] (Heinemann, 1955, p. 95).

Diamond (1960) also attempts an explanation based on the visual system of the enhancement effect reported by Heinemann.

Support for a central interpretation of contrast is given when learned phenomena are involved. As Helmholtz stated:

> My conclusion is, that nothing in our sense-perceptions can

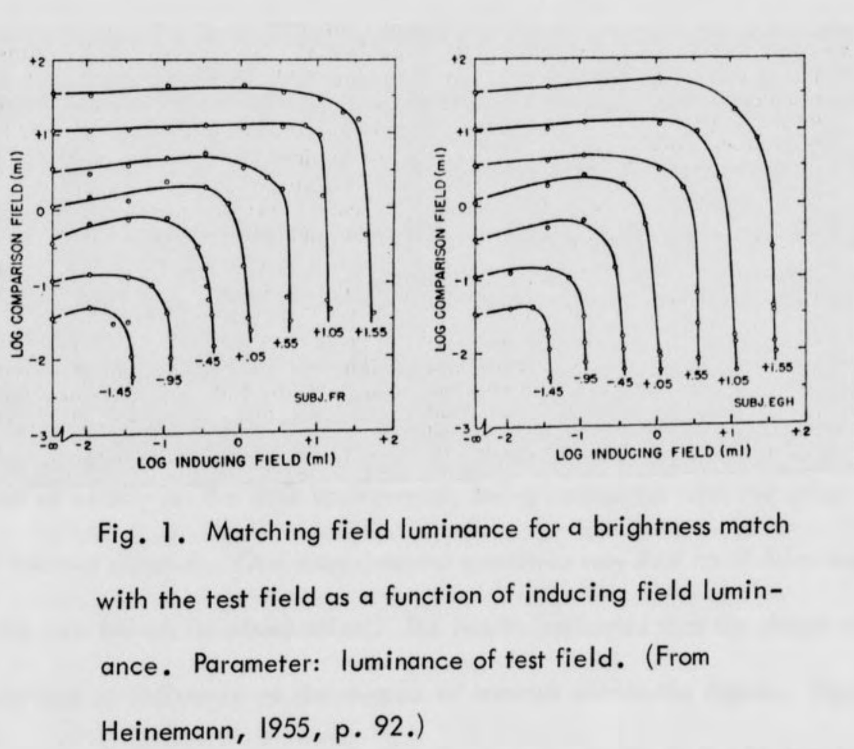

Fig. 1. Matching field luminance for a brightness match with the test field as a function of inducing field luminance. Parameter: luminance of test field. (From Heinemann, 1955, p. 92.)

be recognized as sensation which can be overcome in the perceptual image and converted into its opposite by factors that are demonstrably due to experience (Helmholtz, 1866, Vol. III, p. 13).

To test for an "error of judgment" one can change conditions of judgment without changing retinal stimulation appreciably, and observe whether perception changes.

A recent study by Berman and Leibowitz (1965) illustrates such an approach. They measured the effect of contrast as a function of the orientation of a test object shaped as a figure "8", on a half-light and half-dark background divided vertically. Also varied was the type and width of a contour separating the halves of the figure on the two backgrounds. One group of subjects observed the test figure in a vertical position and another group observed the figure in a horizontal position. In the latter position, each ring of the gray figure "8" was seen as lying wholly on the light background or wholly on the dark background, being connected with the other at the border of the two grounds. One experimental condition was that no divider was placed between the two halves for observation. The results indicated that the shape of the figure itself had an influence on the degree of contrast within the figure. Significantly greater contrast effect was reported when the test figure was in the horizontal, rather than vertical, position. There seemed to be an observer-imposed contour effect.

When dividers were placed between the halves of the figure at the light-dark border of the background, there being eight such experimental conditions, there was considerable change in the reported contrast effect. The dividers used ranged in width from .005 to .64 in. A greater change in contrast effect was reported with the vertical figure under these conditions; however, the overall contrast effect remained greatest with the figure in the horizontal position.

Inasmuch as area is an important variable in contrast, another experiment was designed which incorporated procedures similar to those of the experiment described above. In this second experiment, however, the two halves of the test figure were physically separated so that the area of the figure and the area of the light background remained constant as the width of the divider or "contour" between them was systematically increased. For the vertical figure this separation of the halves of the test figure resulted in significantly more contrast than was reported when the dividing strip was used without separation. Both procedures produced similar results in the horizontal orientation.

It is interesting to note that the smallest divider used in the experiment, which subtended only 30" of arc and which thus corresponded to the angle subtended by an individual cone in the center of the human fovea, was adequate to increase contrast for both positions of the test figure. As Berman and Leibowitz state:

> It is highly unlikely that the effect of a line of this width, which represents approximately 0.2% of the total width of the test object in the vertical orientation and 0.1% of the total width in the horizontal orientation, can be ascribed to changes in luminance or area relationships (Berman and Leibowitz, 1965, p. 255).

The authors conclude:

> It follows that simultaneous contrast is not a simple function of

> luminance and spatial variables. This does not imply that these variables are not fundamental to contrast, but rather that additional concepts are needed to fully explain subjective contrast with more complex stimulus configurations (Berman and Leibowitz, 1965, p. 256).

Another approach to the verification of the "error of judgment" explanation of perception is to change the instructions given the subjects. Woodworth and Schlosberg (1954, p. 421) cite an example in a related area. They report that Benussi varied the instructions given his subjects regarding the observational set to be assumed while viewing the Muller-Lyer illusion. The subjects were instructed to observe first with a "whole-perceiving" attitude and then with a "part-isolating" attitude. The results indicated that the Muller-Lyer illusion was greater when the whole-perceiving attitude was adopted than when the part-isolating attitude was, therefore suggesting a central interpretation of perception.

Riedel is reported by Woodworth and Schlosberg (1954, p. 451) to have observed that a "contemplative" rather than an "object-directed" attitude is favorable for getting contrast colors and that this attitude can be acquired by practice. This observation by Riedel is consistent with the position taken by Helmholtz (1866, Vol. II, p. 295) in the following statement:

> Since most contrast phenomena are dependent on the extent of the uncertainty in the judgment of the intensity and quality of our visual sensations, practice in judging colours is bound to have

> a considerable influence on the appearance of contrast. An eye that is trained in estimating size, distance, etc., will be on its guard against many illusions into which an untrained eye will be betrayed, and it is the same with the determinations of colour; and hence the author's belief is that practiced eyes generally see contrast less vividly than unpracticed eyes.

Careful inspection of Riedel's (1937) study in the original, however, indicates that his observation was made without the benefit of systematically imposed treatments and controls for this specific effect.

To recapitulate, explanations of simultaneous brightness contrast consistent with the traditional nativistic and empiricistic points of view have been presented. Evidence relevant to these views has been cited from experiments employing the techniques of electrophysiology of the retina and from experiments based on psychophysical methods. Inasmuch as electrophysiological evidence, though based on elegant techniques, cannot fully explain simultaneous brightness contrast, the phenomenon is still a controversial issue of theoretical interest.

PURPOSE

It is the purpose of the present experiment to clarify the issues involved in simultaneous brightness contrast.

Originally, the present experiment was intended to measure the changes in brightness of a test field as inducing field luminances were varied. It was hypothesized that if contrast is the result of retinal processes rather than central processes the greatest illusion effect would be obtained for the greatest difference in inducing fields, and if contrast is due to an "error of judgment" there should be a greater contrast effect when the inducing fields were not of extreme differences and therefore more difficult to judge.

In an effort to evaluate this hypothesis, a preliminary study was conducted in which subjects were presented a black inducing field and a white inducing field that were adjacent to each other, each encircling a gray test field seen through a circular hole cut in its center; this schema was suggested by one of Hering's own demonstrations (Hering, 1920, p. 124). The subjects also viewed other inducing fields of less luminance differences designed in the above manner and encircling gray test fields of the same luminances as used with the above surrounds. There were five such sets of surrounds presented; two at each viewing in random sequence. The subjects were instructed simply to judge which set of surrounds resulted in greater contrast between the test fields. The reports varied a great deal, a fact which aroused the curiosity of the experimenter and led to the questioning of the subjects as to how they made their judgments. It was found that widely diverse points of view or observational sets were being taken; and, quite interestingly, there was a consistency between the observational set taken and the subsequent judgment given. This accidental discovery seemed significant and led to the decision to design and carry out the present experiment.

A new experiment was then designed to measure brightness contrast as a function of instructional set. It was this experiment which was actually carried out and which is reported here. An attempt was made to hold the viewing conditions constant for all subjects and to vary a small but crucial portion of the instructions given the subject. More specifically, one group of subjects was given instructions designed to instill a "whole-perceiving attitude" while viewing the stimulus field, and the other group was given "analytical" instructions. The experimental question was as to whether the instructions would influence the subject's perception of simultaneous brightness contrast.

PROCEDURE

Experimental Situation

All experimental work was conducted in a relatively sound-proof, air-conditioned room, 3.15 x 3.96 x 2.01 m. in size. The walls and ceiling were covered with standard "Celotex" blocks, the floor with a cork composition. Light for general use was provided by an overhead 75-w. bulb enclosed in a circular white glass diffuser.

A brown, wooden table, 95 x 185.5 cm., placed in the center of the room, was used to support the experimental apparatus. The subject (S) was seated in a conventional straight-back chair at one end of the table; the experimenter (E) sat behind the apparatus at the other end of the table.

Apparatus

The principal item of apparatus was a framed panel designed to hold two large pieces of construction paper.

The panel was essentially a piece of plywood, 64 x 35 cm., mounted on a 9 x 69 cm. wooden base. The vertical sides of the panel's frame were grooved to hold the two large papers, one of which covered each half of the panel; a metal clip was placed at the top of the plywood panel, on the centerline, to help secure the papers. Two circular holes, with diameters of 8 cm. each, were cut in the plywood, 17.5 cm. from the top and 7.5 cm. to the right and left, respectively, of the centerline. Two wooden wheels, each 23.5 cm. in diameter, were fastened by nut and bolt on the back of the panel, each being allowed to rotate against a thin rubber washer. The two wheels were located 17.5 cm. from the top of the panel and 14.5 cm. to the left and right of the center-line, respectively. The wheels were easily inter-changed by removing the nuts and sliding the wheels off the bolts. The entire panel was clamped to the table, 21.5 cm. from the E's end, and centered on its long axis.

The S sat in the chair at his end of the table, with his head resting in a padded headrest which was clamped to the edge of the table. A distance of 164 cm. separated the headrest from the stimulus panel. At a distance of 5.4 cm. in front of the head-rest, a screen 58 x 76 cm., of curtain sheer cloth, having 69 threads to the inch in the warp and woof, was placed, to diffuse the field and reduce visibility of microstructure and thus to insure favorable conditions for observing the contrast illusion. A 60-w. light bulb in a circular metal reflector, placed 13.5 cm. in front of the screen and just below S's line of vision, provided the only source of illumination during actual experimental procedures. The timing of illumination was controlled by a Hunter timer, set for a 3-sec. "on" interval, which could be activated by E.

Two sheets of paper, to be referred to as the inducing fields, were placed side by side on the panel. Each paper measured 32 x 35 cm. The papers were obtained from the "Color-aid" (sic) Company, 116-120 East 27th Street, New York, N.Y. One paper, the lighter, was designated as "1", and the other, the darker, as "8", by the manufacturer. The paper designated "1" was a shade near white and the "8" was a shade near black. "Black" and "white" were not used as inducing fields because their extreme contrast held the possibility of after-image.

A circular opening with a diameter of 5.3 cm. was cut in each paper, 7.5 cm. from the border formed by the meeting of the two papers, and 17.5 cm. from the top of each paper. Through this opening, and the corresponding opening in the panel itself, S could view pieces of gray Color-aid paper of varying reflectances. A standard paper was chosen ("4"), which always appeared behind the lighter inducing field. Five papers ("8", "7", "6", "5", and "4"), referred to here as test fields 1, 2, 3, 4, and 5, were presented one at a time, on the rotating wheel behind the darker field. The test fields were glued to the wooden wheel in order of their reflectance values.

Since no exact reflectance values were available from the manufacturer, they were estimated by matching the Color-aid papers with an adjustable black-white disc while both were spinning on color wheels. The disc was constructed of the papers designated as "black" and "white" by the manufacturer. Table 1 shows the values of all the papers used, as judged by this technique.

Method

Twenty Ss, 12 female and 8 male, were selected from graduate students and upperclassmen majoring in psychology at the University. Prior to the arrival of the first S, the treatments were randomly assigned to the order of arrival of Ss. Therefore, when a given S arrived for an experimental session, the E checked the schedule, to determine which treatment S was to get, and then imposed that treatment by reading the appropriate instructions.

Table 1

Reflectance Values of Papers Used as Inducing

Fields, Test Fields, and Standard Field

Paper	Manufacturer's Number	Per Cent Reflectance	Subjective Whiteness*
Lighter inducing paper	1	61.10%	82%
Darker inducing paper	8	2.08	15
Test field 1	8	2.08	15
Test field 2	7	5.55	27
Test field 3	6	8.33	33
Test field 4	5	13.88	42
Test field 5	4	19.44	50
Standard field	4	19.44	50

*According to Woodworth and Schlosberg, (1954, p.430)

The actual experimental procedures followed the description given in the instructions to S. If, for example, S arrived and E determined that he was to be in the "whole-perceiving" group, the following instructions were read to him:

> This experiment is an attempt to determine how the eye works when confronted with a lighter-darker type contrast.
>
> Here you see two large sheets of paper, one light gray and one dark gray, each with a circular hole cut in it. Behind these large sheets of paper I will place pieces of gray paper which can be seen through the circular holes. Your job will be to tell me if the piece of paper behind the large, dark sheet is lighter or darker than the piece of paper behind the light sheet.
>
> As you make each judgment, you are to take a "whole-perceiving" attitude. That is, you are to view the perceptual field up here [indicate] as a whole; then you are to give me your judgment about the piece of paper behind the dark sheet based on this "over-all" look at the situation. This will be similar to a "general-impression" sort of judgment.
>
> Your viewing time will be limited to 3 seconds. Then the light will go off [demonstrate]. When the light goes off, please close your eyes and do not open them again until I ask you to do so. When I say "open," open your eyes, make your judgment, close

your eyes, and wait for the next trial. Make your judgments simply by saying "lighter" or "darker," as you see the difference.

You will always be deciding if the piece of paper behind the dark sheet is "lighter" or "darker" than the piece of paper behind the light sheet. However, the dark sheet will not always be in the same position on the apparatus. It will be occasionally changed from your left to your right, and vice-versa, in the course of the experiment. Your eyes will remain closed for this change, but I'll be as brief as possible so as not to cause you any discomfort.

Are there any questions before we begin?

O.K. Now if you will place your face in the padded head-rest and find a comfortable position for your arms, we'll begin.

Now close your eyes, please.

The instructions were given at the beginning of each session, and reminders of the point of view to be taken by S were given after each 10 judgments. S was unaware that other Ss were given different instructions.

At the end of the final session, each S was asked the three questions which follow, and his responses were recorded.

1. How did you make the judgment?
2. Did the light and dark sheets seem to influence the appearance of the discs?
3. Were you concerned about this? What did you do about it?

This sequence of events was followed with each S. The group designated "analytical" differed in procedure from the "whole-perceiving" group only in one part of the instructions. The third paragraph read, in the "analytical" instructions, as follows:

> Pay attention to the pieces of paper behind the large sheets and try to analyze them in comparison to each other. Do not be concerned with the front sheets; in fact, do the best you can to ignore them. You are making judgments about the lightness and darkness of the pieces of paper behind the large front sheets.

As seen in Table 1, there were five test fields. They were presented in random order, each test field being presented twice, to be judged against the standard field, in what was designated as a "set" of judgments. There were thus 10 judgments per set. There were four sets per 20-min. session, for a total of 40 judgments per session. In any given session, the inducing fields were alternated in an a b b a sequence, the shift being made at the end of each set of judgments. The first placement of the darker inducing field on the right or left side was determined randomly. Thereafter the placement for the first set of 10 trials was simply opposite that of the last placement of the preceding session. The room remained dark while the inducing fields were being exchanged.

Each S was tested for four sessions, with no more than one session falling on any single day, for a total of 160 judgments. It was decided in advance that the data for the first session for each S were not to be included for analysis, as this was to serve as a practice session. S was not told of this decision, however. This procedure left 120 judgments per S for analysis, there then being 24 judgments per test patch.

RESULTS

The method of constant stimuli having been employed, a psychometric function was constructed for each S in the present study. The several functions are shown in Fig. 2, where the whole-perceiving group is represented by the upper graph and the analytical group by the lower graph.

In Fig. 2, the number of times a given test field was judged lighter than the standard field is plotted on the left-hand ordinate; the right-hand ordinate gives the same data expressed in terms of per-cent choice. Reflectance values are plotted on the abscissa. The reflectance values of the five test fields are indicated by vertical lines. To determine the extent of the illusion and to compare the two groups, the number of times S judged each test field as lighter than the standard is plotted, and these plots are connected by straight lines. The point at which S would judge the test field and the matching field to be the "same," the point of subjective equality (PSE), was determined by reading the reflectance value on the abscissa at the point where his curve crosses the 50-per-cent horizontal line. The difference between the PSE and the reflectance value of test field five is an indication of the extent of the S's illusion; therefore, curves that are to the left of the graph reflect a marked illusion effect. Inspection of the curves for the two groups suggests strongly that the whole-perceiving group reported a greater illusion effect than did the analytical group.

Three of the curves in Fig. 2 are dashed lines rather than solid. Because consistency of viewing conditions for both groups was a critical consideration, careful

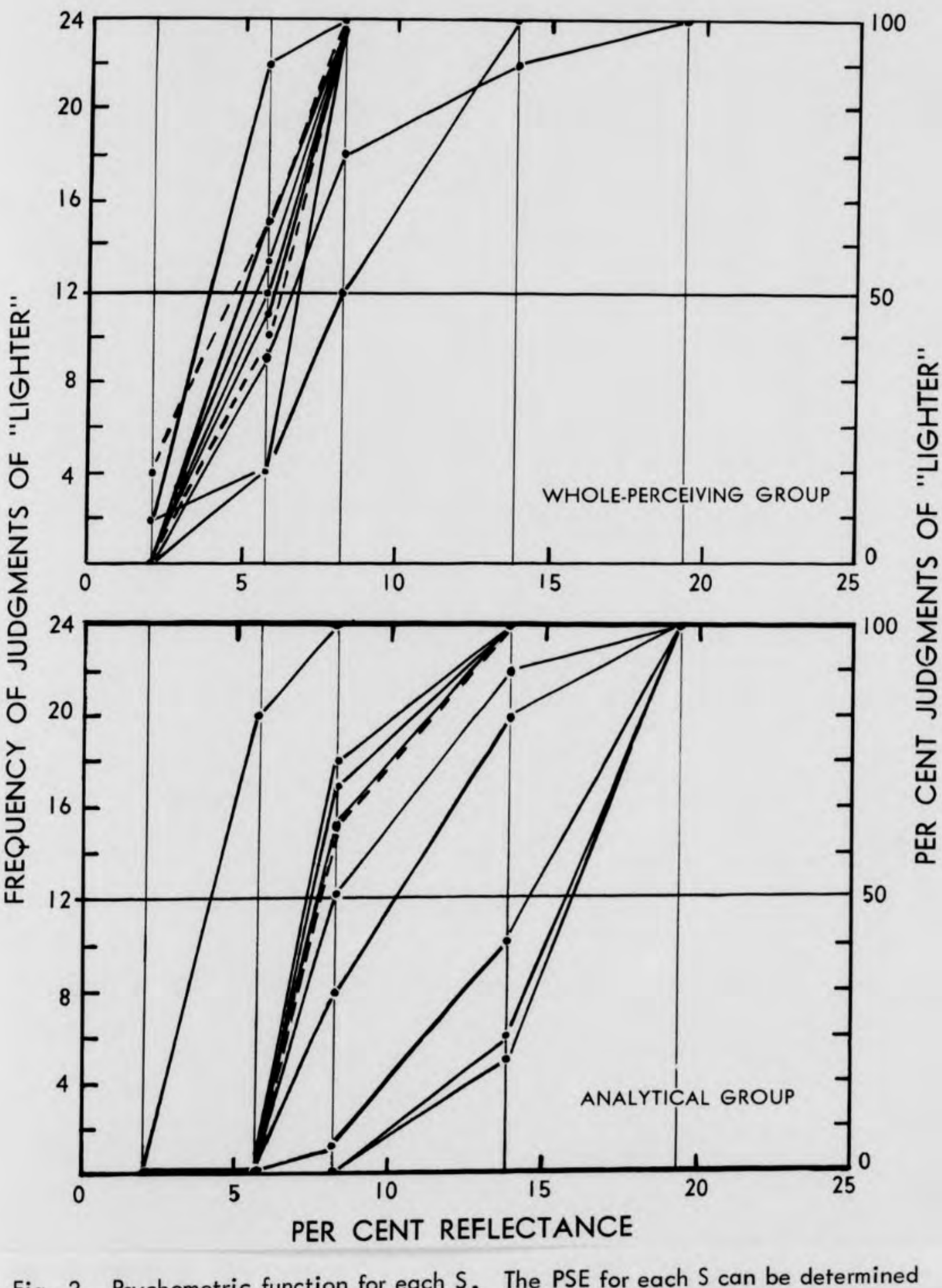

Fig. 2. Psychometric function for each S. The PSE for each S can be determined by reading the reflectance value on the abscissa at the point where his curve crosses the 50-per-cent horizontal line. For explanation of three dashed curves, see text.

attention was given each S's report about how his judgments were made. It was decided, based on statements given by the Ss, that the three Ss represented by the broken lines had tended to look away from the circles to make their judgments. This constituted a significant departure from the viewing procedure of the remaining Ss and introduced a possible contaminating variable; therefore, it was decided to exclude these Ss from any further consideration in the experiment. As will be indicated below, this exclusion was conservative in effect.

For each of the 17 Ss actually employed, the PSE was determined rigorously by linear interpolation, and can be seen in Table 2. An analysis of variance was performed in terms of the PSE's and is summarized in Table 3. The mean PSE for the whole-perceiving group was a reflectance of 5.84 per cent, and the mean for the analytical group was 10.20. The difference between these two means is significant at the .05 level. (A similar analysis, employing all 20 Ss, showed significance at the .01 level.) An analysis for homogeneity of sample variance yielded an F of 10.22, which exceeds the criterion value at the .01 level and indicates non-additive treatment effects.

The use of parametric statistics in connection with the present data is questionable for at least one reason--namely, that the reflectance values assigned to the stimuli in this study were actually estimates. It is thus possible that the reflectances assigned to the test fields were somewhat in error, and that all one could reasonably assume is that the <u>order</u> of the magnitudes of these reflectances (specified by the manufacturer and clearly correct) is valid. It is to be noted that, even with this minimal assumption, the <u>order</u> of the magnitudes of the Ss' respective PSE's would

Table 2

Point of Subjective Equality for Each S, in Per Cent Reflectance, by Linear Interpolation

(Values enclosed in parentheses were those omitted in statistical analysis. See text.)

Whole-Perceiving Group PSE	Analytical Group PSE
3.82	4.16
(4.61)	7.38
4.86	7.52
5.27	(7.77)
5.55	7.77
5.81	8.33
(6.02)	10.16
6.47	14.66
6.58	15.72
8.33	16.17

Table 3

Analysis of Variance of PSE's of Analytical and Whole-Perceiving Groups

Source	SS	df	V	F
Between Analytical and Whole-Perceiving Groups	80.93	1	80.11	7.53*
Combined Within-Sample or Error	159.62	15	10.64	
Total	240.55	16		

*$P < .05$

remain invariant. The two groups can thus be compared rigorously in terms of the Mann-Whitney U-Test. When they are, they are found to differ at the .02 level of significance. (The same analysis, performed with all 20 of the original Ss, shows significance at the .01 level.)

It is to be recognized that each S may have been more or less successful in assuming the perceptual attitude assigned to him. The purpose of the questions asked of S at the end of his session was to obtain information on that point. The information actually secured was put to use in another system for scoring as now described below.

The statements made by each S at the end of the final session were submitted without identification to two members of the psychology faculty, who served as raters. The raters were furnished copies of the instructions given the two groups of Ss and instructed to rate on an 11-point scale, from 0-10. A value of 0 was used to signify that the rater judged that S took a completely analytical set, and a value of 10 signified that S took a completely whole-perceiving set. Values between 0 and 10 were assigned to and represented equal intervals between these extremes. The raters were also allowed to signify an inability to rate any given S's statement. A Pearson product-moment correlation coefficient was derived as an index of interrater reliability. Its value was +.83, significant at the .01 level. An analysis of variance was computed for the PSE's of the 10 Ss judged by both raters as having definitely taken either a whole-perceiving or an analytical set. The result of this analysis is presented in Table 4, and is seen to be nonsignificant. When a Mann-Whitney U was computed from the same data, it too showed nonsignificance.

Table 4

Analysis of Variance of PSE's of Ss Judged by Raters to Have Taken Whole-Perceiving and Analytical Sets Respectively

Source	SS	df	V	F
Between Whole-Perceiving and Analytical Groups	19.43	1	19.43	1.32*
Combined Within-Sample or Error	117.66	8	14.70	
Total	137.09	9		

$^*P > .05$

DISCUSSION

The results of the present experiment provide quantitative evidence that the attitude of the S, as defined by instructional set, influences the perception of simultaneous brightness contrast. A significant enhancement of reported contrast was associated with instructions to adopt a "whole-perceiving" attitude rather than an "analytical" attitude. Inasmuch as careful attention was given to the control of the stimulus field, to insure that the retinas of all Ss were stimulated in the same manner by light waves from the entire contrast field, it can be concluded that central variables were responsible for the resulting differences between the two groups.

The difference in instruction actually had two effects: (1) a change in perceived brightness between groups, and (2) a change in the range, or spread, of judgment, as between the two groups.

The change in perceived brightness is striking when considered in terms of subjective whiteness. The mean PSE for the whole-perceiving group was a reflectance of 5.84 per cent, and the mean PSE for the analytical group was 10.20 per cent. These reflectances correspond to subjective whitenesses of 27 per cent and 40 per cent, respectively (Woodworth and Schlosberg, 1954, p. 430). The subjective whiteness of the matching field was 50 per cent. The extent of the difference in the effect, as between the two groups, can be illustrated by transforming these values to a measure of relative illusory effect. Thus, the analytical group had a 20 per cent illusory effect, and the whole-perceiving group had a 46 per cent effect.

The results here are consistent with Helmholtz's view that contrast phenomena are due to "errors of judgment" and supportive of the conclusion of Berman and Leibowitz (1965), that concepts are needed in addition to those of retinal reference if simultaneous brightness contrast is to be explained completely. The results here are also consonant with Riedel's (1937) informal observation of the apparent effect of S's attitude on perception of simultaneous contrast.

It is of interest that the test of homogeneity of sample variance also was significant, indicating that the effect of the independent variable differed from S to S, with the greater spread of judgments falling in the analytical group. A plausible explanation of this effect would be that the analytical attitude is more difficult to assume than is the whole-perceiving attitude. Such an explanation is consonant with Helmholtz's statement that Ss can improve in ability to make analytical perceptive judgments with practice.

Any attempt to control the attitude by the use of instructional set leaves some uncertainty as to whether or not the instructions were understood and followed by the Ss. The questions asked each S at the end of his final session were intended in part to give some indication to the E of the set taken by the Ss in this experiment. The analysis of variance of the resulting data, summarized in Table 4, was not significant at an acceptable level. This outcome was expected, due to the small sample (N=10) available for analysis.

It is noteworthy that, in response to the questioning, some Ss reported that they felt their judgments were being influenced by the surrounds. The reports indicate that some of these Ss attempted to account for this influence in the formation of their judgment. Such influencing factors would seem to be directly related to the effect of past experience in making this kind of judgment.

The effects of set on simultaneous brightness contrast were fairly compelling in this experiment. An extension of this experiment on a refined level, however, would no doubt yield even more pronounced effects. A more precise method of controlling and designating the levels of luminances of the test, matching, and inducing fields would be an improvement. The psychophysical method of adjustment rather than the method of constant stimuli could be employed advantageously (Diamond, Scheible, Schwartz, Young, 1955). Ss with experience in making psychophysical judgments could be used; it would then be possible to use each S as his own control, thus revealing the central influence on perception in a convincing manner.

SUMMARY

Explanations of simultaneous brightness contrast consistent with traditional nativistic and empiricistic points of view have been presented. Evidence relevant to these views has been cited from experiments employing the techniques of electrophysiology of the retina and from experiments based on psychophysical methods. Inasmuch as the evidence is not conclusive and the theoretical issues remain controversial, this experiment was designed in an attempt to aid in clarification of these issues.

A nativistic, or peripheral, explanation of simultaneous brightness contrast is based on a visual response mechanism in the retina; and an empiricistic, or central, explanation is based on past experience and learning; therefore, the experimental question here was whether instructions given the S would effect the degree of simultaneous brightness contrast. These instructions were designed to instill a "whole-perceiving attitude," on one hand, and an "analytical attitude," on the other.

Twenty Ss, 12 female and 8 male, were selected from graduate students and upperclassmen majoring in psychology at the University. They were randomly assigned to two groups, one group receiving "whole-perceiving" instructions, and the other group receiving "analytical" instructions prior to observation of the simultaneous brightness contrast situation. Each S had four experimental sessions, with no more than one session falling on any single day.

Statistical analysis revealed a significant difference between the results of the two conditions of observation of simultaneous brightness contrast. A significant

enhancement of reported contrast was associated with instructions to adopt a "whole-perceiving" attitude rather than an "analytical" attitude. These results suggest that simultaneous brightness contrast can be best considered within a traditional empiricistic framework.

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