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PERCEPTION OF APPARENT DEPTH AS A FUNCTION OF ILLUMINATION INTENSITY IN THE CASE OF A RELATIVELY UNSTRUCTURED STIMULUS

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PERCEPTION OF APPARENT DEPTH AS A FUNCTION OF ILLUMINATION INTENSITY IN THE CASE OF A RELATIVELY UNSTRUCTURED STIMULUS

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CHAPTER I

INTRODUCTION

Within the field of psychology, a large gap seems to exist between applied and theoretical psychology. During a relatively short period of time clinical psychology has developed methods, tools, and clinical theories with an emphasis on application. This has apparently been done mostly in terms of "clinical experience" with little effort to demonstrate congruence with existing theoretical foundations. Experimental psychology has likewise produced a great number of facts and theories. Theoretically, since both areas deal with human psychology, one would expect a tendency toward convergence in theories and concepts. Actually, there seems to be little evidence of such a trend; instead, it would seem that movement is proceeding in parallel or divergent directions. Of course, clinical psychology pays lip service to the theoretical psychology of the experimentalists, but it would seem more usual that clinical problems are dealt

with in terms of empirical results with minimal concern for theoretical foundations based on strictly experimental findings. Many clinicians seem to feel that academic psychology, on the other hand, has never really begun to tackle the many theoretical problems presented by the empirical results of clinical work. A few attempts have been made to fit clinical facts into existing experimental theories; as yet none seems to have been more than a poor fit.

In a recent article, Ruth Tolman incisively discusses this problem. After developing her arguments from the history of science and medicine, she points out that "it tends to be characteristic of the development of many sciences that practice runs ahead of theory. . . . Practice without theory remains an art or a technique and never becomes a science" (20, p. 721). In these two statements, the realities of the split in psychology seem to be neatly wrapped up.

A concrete example of the problem as it exists is found in the Rorschach test, an important clinical tool. This test has been used for forty years, but experimental psychology has yet to deal with the many useful factors employed in Rorschach scoring and interpretation. Experimental psychologists have not attempted to "explain" the Rorschach nor to fit it into present theory. Clinical workers on the other hand have been content to deal with the test at a strictly empirical level, with little

apparent concern about basic perceptual theory.

Herman Rorschach pointed out the facts concerning the Rorschach test in the introduction to Psychodiagnostics and opened the door to research at the theoretical level. He states:

> At the outset, it must be pointed out that all of the results are predominantly empirical . . . . The conclusions drawn therefore are to be regarded more as observations than as theoretical deductions. The theoretical foundation for the experiment is, for the most part, still quite incomplete (17, p. 14).

At present the theoretical foundations for the Rorschach are still uncharted territory. Bruner, a perception theorist, describes the situation clearly:

> It seems apparent that Rorschach methodology and the interpretation of Rorschach responses are closely linked to the development of perceptual theory. Perceptual theory, in the past so neglectful of personality dynamics, has on its part the task of contributing a full understanding of why such techniques as the Rorschach have been successful (4, p. 167).

In addition to the fact that there is a definite need for an adequately established theoretical foundation for the Rorschach test, it seems reasonable to assume that if the Rorschach does involve significant aspects of perception which have not yet been explained or which cannot be explained in terms of present theory, then one would expect that new facts could be derived from experimental study of perception as here employed.

Based on the orientation discussed thus far, a

series of preliminary experiments were undertaken in an attempt to differentiate aspects of perception of the Rorschach ink blot which could be studied experimentally. These preliminary experiments are described in the following chapter and the remainder of this thesis consists of tests of the validity and meaning of two related conclusions derived from these exploratory efforts.

CHAPTER II

PRELIMINARY EXPERIMENTS AND DEVELOPMENT OF THE PROBLEM

The preliminary experimentation was undertaken at a purely exploratory level, with no specific expected outcome. The first step in this exploration involved the use of a technique described by Gibson (6, p. 166). According to Gibson a dim light is sometimes used in perception experiments to reduce the "adequacy" of the stimulus and to produce effects which may be useful in the study of perceptual processes. With this technique in mind, it was reasoned that reduction of illumination on a Rorschach plate would result in reduced structuredness in perception of the plate, and that variation of illumination would produce differential effects in reported perceptions.

In order to test this reasoning a simple procedure was developed to vary the illumination on the Rorschach plates. First, a rheostat was connected in series with an ordinary desk lamp. All other lights in the room were turned out, making it almost totally dark. Then the rheostat was slowly turned so that the light came on gradually and was increased in intensity by small steps. The subject

held one of the Rorschach plates and reported everything that he saw. The author and his wife made numerous trials under these conditions with encouraging results. At the very lowest levels of perceptible illumination, it was found that vague, shifting forms appeared. As the intensity was increased, these vague forms became stabilized and appeared as organized percepts. As the light was further increased, the first organized percept sometimes disappeared and a completely new one appeared in its place. For example, the card might first look like a cat and at a slightly higher illumination appear to be a person. With still further increase in illumination, the blot seemed to become flat, the object meaning that was present seemed to vanish, and the card was seen simply as an "ink blot." When the illumination was decreased gradually, the original percepts reappeared, but in reversed order.

Since it seemed likely that these initial results were of some significance, it was decided that an apparatus should be designed which could be used practically with a large number of subjects. Due to the fact that some perception is present at very low illumination, variation of the room illumination appeared impractical because of the difficulties involved in making a room light-tight and still comfortable in the middle of summer. This problem was solved by the construction of a box which was the same width and height as the Rorschach card and the same length as the

average distance between the card and the eyes in the conventional Rorschach situation. The latter distance was approximately determined as 16 inches. Part of a pair of binoculars was used as the eye piece, and a small light was installed in the top of the box. The light was connected to a variable transformer. This allowed the subject vision with both eyes in a situation where the nature of the stimulus and the light intensity were under the control of the experimenter.

Initially, it was assumed that the best results would be obtained if the whole series of ten Rorschach cards was used with each subject. With the above described box, a set of Rorschach cards, and a parallel series of Behn Rorschach cards, about twenty naive and sophisticated subjects were studied. The naive subjects were undergraduate male volunteers from a university dormitory, and the sophisticated subjects were colleagues in the graduate Clinical program of the Psychology Department.

In most cases, the procedure involved simply telling the subject to "look in the eye pieces and tell me everything that you see." The intensity was increased until the subject reported that he saw something, then the experimenter stopped to write down the response. When the subject finished reporting what he saw, the illumination was again increased at a slow rate. After the maximum voltage was reached the illumination was decreased at a slow rate to the

point at which the subject reported "I don't see anything." The subject reported continuously. After completion of the entire series of cards he was asked to discuss what seemed to happen. A record was kept of each voltage which coincided temporally with each verbalization.

It was found that the level at which people began to "see something" was about the same for all of the subjects in this preliminary series. No data are available concerning the actual illumination values involved in this preliminary experimentation, so the illumination is considered in terms of voltage and relative intensity rather than actual illumination. Most subjects reported an initial percept which involved shape only. These initial percepts were rather consistently simple, uncomplicated objects such as "bear," "dog," etc. As the illumination was increased slightly above the level at which this first form percept appeared, the blot was seen in more detail and the organization of the percept frequently changed. Further increase in intensity resulted in further changes in organization and, oftentimes, in meaning. For example, some subjects modified and amplified the original percept, as in the case of the person who saw an airplane first, then a bird, then a man with wings. Other subjects discarded their original percept and substituted a completely new one when the intensity was increased. In terms of area of the blot used, some people broke down the large whole, which they originally saw, into

smaller percepts, while others maintained the original whole percept either with modified or completely changed meaning.

Changes in size were frequently reported such as "It's getting larger as the light increases" or "It's getting smaller" as the intensity decreased. Apparent movement of the blot away from or toward the subject was also frequently reported. In one instance the subject reported that the black shape of the ink blot had detached itself from the card and was floating half way back in the box, while the card itself had receded to a distance somewhere back of the box. When the illumination was increased, the ink blot appeared to move forward until they were no longer separated. Reduction of the illumination again resulted in separation.

Most of the sophisticated subjects reported "It's moving" when they saw the first, low intensity percept. This movement took the form of "wings flapping," "faces smiling and then frowning," "his arms moved," etc. However, none of the naive subjects reported this phenomenon, and no method has yet been discovered by the experimenter to determine the presence or absence of the movement phenomenon without first suggesting it directly or indirectly. Several of the sophisticated subjects who reported this phenomenon had no previous knowledge that such movement might occur. One might tentatively set up the hypothesis that either sophisticated clinical students are different in some

significant aspect of their perception or that the naive subjects were highly threatened by such "impossible" perceptions and preferred not to report what they saw.

Judged by comments of subjects and observation of their behavior in the experimental situation, it is apparent that the procedure was extremely threatening. Several subjects' comments indicate that the subject would "see something" (at low illumination) and then before his eyes it would suddenly change into something else. The subject knew that nothing had really changed except the illumination intensity and that it was "impossible" for something to change so drastically from such an elementary cause. The net result was a feeling on the part of the subject that he was losing his own internal anchorages, or, more concretely, he felt he was "cracking up." This sort of threat was very severe in some cases.

The responses obtained from these subjects when the light was reduced were similar to those obtained when the light was increased, but in reverse order. In most instances, when illumination was decreased the percepts changed back to what had been seen earlier. However, there was one instance in which nothing was seen at the lowest level, and the illumination reached a relatively high level before any percept was reported. The percept reported was "A beautiful spring, with flowers and green grass." When the illumination was again reduced to a low level, the

subject suddenly seemed frightened and reported that he saw a "horrible monster--an old man." From the clinical point of view, it seems likely that initially his feelings were too threatening to be expressed. However, after the "beautiful spring" had appeared he was less threatened and the percept originally avoided became tolerable.

About a third of the subjects reported another phenomenon. When illumination was increased to a high level and was then reduced to low level intensity, completely new percepts sometimes appeared, determined by a sudden appearance of white space as figure where formerly the white space was seen as ground. No satisfactory explanation has been discovered for this particular phenomenon, but it is possible that some clues may be present concerning the nature of white space perception in the Rorschach itself and possibly some aspects of figure-ground reversal also.

A sample of the data obtained in these preliminary experiments may be found in Appendix I.

Early in the first exploratory experiments, the author noticed that the "depth effect" in the card seemed to vary according to the illumination. Also, it seemed that the meaning became less and less important or involving, when the illumination was high. These phenomena were spontaneously reported by many of the naive and the sophisticated subjects, and eventually the experimenter made some rough attempts to establish the nature of this variation in

depth and meaning. Subjects were asked to "estimate the point at which the greatest depth occurs." The estimates varied. All of the subjects reported a maximum at some point in the lower ranges of illumination and indicated that there was less apparent depth above and below that maximum point.

Examination of the sequence of responses obtained at the different illumination levels resulted in the tentative suggestion that "a deeper level of the unconscious" is tapped by the responses given in the range of illumination slightly above the minimum level for perception. The responses given at this level seem to be "personal F-minus" responses, or bizarre, threatening, or "strange" percepts when compared to responses given at higher levels of illumination. This particular observation could not be adequately validated with the experimental data gathered, but at a subjective level, within the limits of the judgment of the experimenter, it seemed to be true. One rather clear-cut observation was made in terms of the meaning present at high levels of illumination. Many subjects commented at this level that "it doesn't look like anything--it's just an ink blot." One might evaluate the sequence of responses as an increasing tendency to see the blot as it is, i.e., as an ink blot, as illumination is increased, in contrast to a tendency at low illumination levels to see the blot as something determined by the subject's own internal needs.

From all of these interesting results, one can set up a number of hypotheses for further study. One could not hope to investigate all of these problems in a single piece of research. It did seem possible, however, to pick out important issues from these results and investigate them thoroughly as specific research problems. After examining the results many times, it was decided that the factor of "variation of apparent depth as a function of illumination" was worthy of more precise investigation. This choice was made on the basis of the importance of "depth" as seen in shading and vista responses in the Rorschach and because this particular perceptual phenomenon has never been investigated experimentally. A thorough search of the literature was made, but no reference to variation of depth as a function of illumination was found. Initially, it was thought that demonstration of this perceptual phenomenon would result in a new, discrete "fact" to be integrated with the present body of perceptual "facts" and that it might also shed some light on the present day problems in Rorschach theory concerning shading and depth-determined responses. The immediate problem became that of conclusive demonstration that apparent depth, as seen in the ink blot, varies according to illumination.

Since preliminary experiments suggested that depth effect varies in a definite pattern, the problem also involves demonstration of the relative degree of depth at

different levels of illumination. More precisely, the problem may be stated in terms of two hypotheses. These are:

> Hypothesis I: In a relatively unstructured gray-black ink blot, apparent depth is perceived to a different relative degree when the blot is presented under different intensities of illumination.
>
> Hypothesis II: In a relatively unstructured gray-black ink blot, a maximum depth point will be found at some illumination level, and the depth perceived at higher or lower illumination levels will be progressively less than that at this maximum point.

With the problem finally stated, the next step was that of devising methods for verification or refutation of these hypotheses.

CHAPTER III

METHODOLOGY

With the preliminary results and hypotheses in mind, the problem became that of obtaining judgments of relative depth at varying illumination intensities. Stevens (19) presents a concise and useful summary of the various methods that can be used effectively in dealing with psychological experiments. Rank ordering according to various psychophysical continui is considered by Stevens to be one of the major "occupations" of experimental psychology. However, there are many variables which seem to have "obvious" relationships with physical dimensions, and psychology has assumed that these "clear-cut" relationships may be used without further investigation. Stevens points out that

> As a rule the psychophysicist does not feel obliged to undertake the rank ordering of stimuli that have convenient physical dimensions when one of the dimensions is clearly a monotonic function of the attribute under question. . . . But neglect of the obvious has its hazards and some relations that are assumed to be monotonic might, under closer scrutiny, reach a maximum and double back on themselves (19, p. 38).

In order to establish the necessary rank ordering, Stevens suggests the use of the psychophysical method of "Paired

Comparisons." In this situation, the stimuli are presented in pairs and "each stimulus is paired with each other stimulus. The observer indicates which of the pair is greater in respect to a given attribute" (19, p. 43).

This method would appear to be directly applicable to the problem in question. Determination that apparent depth varies according to some predictable relationship with respect to illumination does not require that one measure the "amount" of depth perceived but does require that one determine which illumination level produces the greatest depth effect, and what relative depth effects are obtained within a given set of illumination values. The only physical variable involved is illumination, and, therefore, one may effectively predetermine a set of illumination values along this physical continuum, and then subjects would be expected to make judgments of "greater" or "less" depth effect successfully when two illumination values are paired if depth effect varies. By presenting each illumination level paired with each other illumination, one may derive a set of judgments from subjects which may then be considered in terms of the proportion of judgments of greater depth effect. These proportions may then be compared in numerical or graphical form, and the nature of the relationship between illumination level and apparent depth may be determined.

Certain real limitations are present in data of this kind however. Since no "measurement" of quantity is made,

and since one does not "know" anything about the quantitative difference between relative depth levels, the usual statistical methods cannot be used to establish the theoretical probabilities of general applicability of the results. According to Stevens,

> Most of the scales used widely and effectively by psychologists are ordinal scales. In the strictest propriety, the ordinary statistics which involve means and standard deviations ought not be used with these scales, for these statistics imply a knowledge of something more than the rank order of data. On the other hand, for this "illegal" statisticizing there can be invoked a kind of pragmatic sanction; in numerous instances, it leads to fruitful results. Although outlawing of this procedure would probably serve no good purpose, it is proper to point out that means and standard deviations computed on an ordinal scale are in error to the extent that the successive intervals on the scale are unequal in size. When only the rank order of data is known, we should proceed cautiously with our statistics, and especially with the conclusions we draw from them (19, p. 26).

Stevens points out that percentile measures may be used with rank order data, but interpolation between intervals is "wholly out of bounds" (19, p. 27). Rank order correlation may be used if the "coefficient is interpreted only as a test function for a hypothesis about order" (19, p. 27). These restrictions are not considered prohibitive, since the data obtained by the method of paired comparisons readily lend themselves to graphical analysis, Chi square analysis, and non-parametric statistical analysis.

With this method in mind, a plan was set up for the equipment and the experimental design. For the method of

paired comparisons one must have a situation in which two percepts may be easily compared. The two stimuli must be presented under identical conditions, with the exception of a single variable condition. In this particular problem the equipment must be designed so that illumination may be effectively controlled, and the distance of the plate must always be the same so that subjects may effectively compare "depth effect" under two different illumination conditions.

The first equipment designed to satisfy these conditions consisted of two equally dimensioned boxes placed such that the second box (A) was on top of the first box (B). Separate illumination sources were provided, and slots were made permitting the subject to see either plate by simply shifting his eyes. Plate VI of the Rorschach test was selected as the stimulus since it is achromatic, has a large variety of shading effects, and commonly is seen as shading or vista in the conventional Rorschach situation. The illumination sources were two 40-watt pencil type bulbs for each box placed in the two corners of the box farthest from the plate. Illumination intensity was controlled by two variable transformers in circuit with the bulbs. Room illumination was controlled initially by experimentation at night in a room which had no light except from a single 40-watt gooseneck desk lamp.

Using a standard GE photoelectric cell, measurements were made of the actual illumination reflected from

the ink blot at the various voltage settings. A curve was drawn of these illumination values on log-log graph paper. According to the IES lighting handbook (9, pp. 6-10), Dr. Meyer (12), of the University of Oklahoma Physics Department, and Dr. Almquist (1), of the Electrical Engineering Department, illumination level is an exponential function of voltage input to an incandescent light source. Therefore, if one plots the data on log-log paper, one would expect to find a straight line curve. This proved to be the case, and it was concluded, with the concurrence of Dr. Meyer and Dr. Almquist, that one might accurately extrapolate the curve for the illumination levels below the lowest range of the photoelectric cell. This was necessary because the photoelectric cell could not be read accurately below about four foot candles, and the illumination range used in preliminary experiments included values considerably lower than that figure. Certain inaccuracies may actually be present in the illumination values which have been extrapolated due to some slight color shift or to error in the curve of the particular bulb used. However, the equipment necessary for getting a highly accurate measurement in this range is not available, and both Dr. Almquist and Dr. Meyer concluded that extrapolation would give figures which were reasonably accurate. Dr. Meyer stated that "the accuracy in this range should be within ten percent" (12). Since relative measures are being made, and since the primary objective of

illumination measurement is to establish data which could be duplicated, it is felt that extrapolation is a satisfactory method.

Trials were set up covering all possible paired combinations of twenty-four illumination steps for the range .018 foot candles through 100 foot candles. Several subjects were run under these conditions, and the overall results showed a tendency in the direction of the results predicted by the hypotheses. However, when the data were analyzed, a very large constant bias was found for seeing greater depth in box A. From the comments of one subject it was discovered that the angle of observation of the card made a great deal of difference in the perceived depth effect. Specifically, a glare effect was present in one box and not in the other. This result necessitated redesigning the equipment. Another problem appeared in these trials. Subjects were not required to do anything but sit, look into the boxes, and judge whether "A has the greatest depth" or "B has the greatest depth." The simple repetitive task proved extremely monotonous.

Two additional requirements were thus placed on the equipment. It appeared necessary that the subject observe both conditions of illumination from exactly the same angle and that he be given something to do to relieve the monotony. With this in mind, the final experimental equipment was designed. Two pairs of bulbs with aluminum foil

reflectors were installed in one box, and the electrical circuit was redesigned so that the subject could manipulate a switch which would connect one or the other pair of bulbs. Since some difficulty had been discovered in setting voltage accurately in the first setup, two electronic voltmeters were added to the circuit to permit greater accuracy in setting the two variable transformers. This equipment is described most effectively by the drawings found in Appendix II.

Further preliminary trials suggested that the constant error had been eliminated and that the task of the subject was now more interesting. With the equipment adequately constructed, the next problem to be considered was the main experiment.

CHAPTER IV

THE EXPERIMENT

During preliminary experiments it was tentatively concluded that as one increased the intensity of illumination from zero, the depth effect seemed to become more marked, reach a maximum, and then continuously decrease. This pattern seemed to hold with all of the preliminary subjects, and it was further found that the maximum depth point appeared at some intensity below 3.2 foot candles. Therefore, it was deemed unnecessary to cover a range much beyond this point in the actual experiment. On the basis of the preliminary data, one would expect the pattern to hold if a larger range was used. All preliminary subjects had reported "less than maximum" or zero depth at about .032 foot candles, so the lower limit was set one step below this level. The total range of illumination chosen to be considered was from .018 foot candles to 5.70 foot candles. Spacing of illumination levels was determined by establishing ten linearly equal spaces along the ordinate (illumination) of the graph of illumination versus voltage. This established eleven points, and the voltage levels which will

yield these eleven illumination levels were obtained from that graph.

With these points established, a matrix was set up which involved two combinations of each illumination level with each other level, or two complete sets of fifty-five combinations with a total of 110 comparisons. These two sets of comparisons are identical with the exception that the circuit orders are opposite, thus making possible an evaluation of error due to differences in the two illumination circuits.

The 110 combinations were then listed and numbered. The numbers 1 through 110 were then drawn from the table of random numbers found in Lindquist (11, p. 262), and the combinations were then rearranged in random order. This random arrangement of trials is deemed necessary to reduce the error due to "expectancy" based on the just previous trial and to randomize the effects of extreme illumination levels upon judgment. The list of combinations used in the experiment can be found in Appendix V.

This design satisfies the requirements of the paired comparisons method, and the arrangement of trials permits randomization of halo effect between trials and error due to expectancy. Further, a direct check of error due to any differences in the illumination circuits is possible. The results obtained from this design may be easily converted to "percentages greater depth" for any given illumination level.

Subjects

The subjects used in this experiment were volunteers from elementary psychology classes at the University of Oklahoma. Four females and four males served as subjects in this final experiment. All subjects were "naive" with respect to the problem dealt with in this experiment.

Procedure

Session I: Subjects were brought into the experimental room and seated in a chair in front of the apparatus. Illumination in this room was controlled by sealing off all windows with aluminum foil and using a single 25-watt bulb in a gooseneck desk lamp for the purpose of reading meters and recording data. The apparatus was adjusted so that the subject could look into the box comfortably while instructions were being given. This initial period took about 10 minutes and was deemed important in that it provided a brief adaptation period for all subjects.

The circuit control switch was placed on circuit A and the subject was shown how to manipulate the illumination with the variable transformer. He was then told to "adjust the illumination down to the point at which the blot appears about to disappear completely." When the subject seemed satisfied that he had reached that point, the experimenter adjusted the transformer up and down in that general area several times, asking the question, "Do you see the blot

now?" After the brief adaptation period an approximate perception threshold was thus established for each subject. A longer period of adaptation would have resulted in a lower threshold, but this has been rationalized in terms of the dark adaptation curve (16, p. 124). The dark adaptation curve is known to drop sharply and then decelerate. Thus, with ten minutes brief adaptation one would expect to get results dealing with the portion of the curve in which adaptation has decelerated and is changing only very slowly.

Subjects were then shown how to manipulate the switch and told that their task was to flip the switch back and forth and to judge which of two illumination levels seems to produce the greatest depth effect <u>in</u> the ink blot. As soon as the subject seemed to understand these directions, trials were begun. The complete series of 110 trials was run, with the subject responding "A" or "B" according to his judgment of "greater depth" with reference to each combination of illumination levels.

Following completion of the series of trials, the subject was asked, "Did it look like anything to you during the experiment?" Then, "Did you use any particular area of the ink blot in making your judgments, or was it the whole thing?" Any additional comments or behavior were also recorded.

<u>Session II</u>: Two days later, Session II trials were run with each subject. Session II involved exactly the same

procedure, with one addition. Following this session, each subject was asked to describe his experiences in the experiment, and to describe the differences, if any, in depth effect at different illumination levels.

Results

The results obtained from this experiment are in the following forms for each of the eight subjects:

Session I: Series A

One judgment of each illumination level compared with each other illumination level.

Series B

One judgment of each illumination level compared with each other illumination level.

Threshold level.

Percepts seen in ink blot (content).

Area of ink blot used.

Session II: Series A

One judgment of each illumination level compared with each other illumination level.

Series B

One judgment of each illumination level compared with each other illumination level.

Threshold level.

Percepts seen in ink blot.

Area of ink blot used.

Subjective comments on experience in experiment.

Series A and series B designations in this outline are derived on a basis of the previously discussed differences between circuit orders. In recording the data, the results for each circuit order were recorded separately and then reflected to fill out the rest of the matrix. For example, the results of a given trial which involves a setting of 15.5 volts (A) compared with 30.5 volts (B) would be entered as information concerning the subject's response to 15.5 volts as compared to 30.5 volts and in response to 30.5 volts as compared to 15.5 volts. The second entry was made by simply reversing the sign of the original response.

The results of the experimental trials for each of the eight subjects are reported in Table 1 in terms of percentages "greater depth" for each illumination level. In Table 2, the total number of responses "greater depth" for each illumination level is reported for the following: Session I, Session II, Series A Total, Series B Total; Females; Males; and Total. In Table 3, the same information is reported in terms of percentages greater depth. Mean values are identical to these percentages if the decimal point is set over one space to the left.

Table 4 lists the approximate threshold of perception for each subject for each session, the mean for each subject, and the mean for eight subjects in terms of volts input to the illumination source.

TABLE 1

PERCENTAGES "GREATER DEPTH" FOR EACH ILLUMINATION LEVEL FOR INDIVIDUAL SUBJECTS

EIGHT SUBJECTS

Subject	Illumination Level 1	2	3	4	5	6	7	8	9	10	11
					Females						
S_1	70.0	95.0	82.5	77.5	62.5	50.0	45.0	32.5	25.0	10.0	00.0
S_2	27.5	97.5	90.0	77.5	70.0	60.0	42.5	40.0	27.5	12.5	5.0
S_3	5.0	77.5	90.0	92.5	70.0	62.5	47.5	45.0	30.0	20.0	10.0
S_4	0.0	15.0	52.5	85.0	87.5	82.5	62.5	57.5	50.0	30.0	27.5
					Males						
S_5	0.0	22.5	67.5	77.5	97.5	82.5	57.5	55.0	45.0	27.5	17.5
S_6	90.0	85.0	80.0	70.0	60.0	52.5	45.0	35.0	20.0	12.5	0.0
S_7	0.0	15.0	62.5	82.5	85.0	72.5	72.5	50.0	45.0	35.0	30.0
S_8	0.0	10.0	20.0	35.0	57.5	82.5	77.5	90.0	77.5	55.0	45.0

TABLE 2

NUMBER OF RESPONSES "GREATER DEPTH" FOR EACH ILLUMINATION VALUE

EIGHT SUBJECTS

	Illumination Levels										
	1	2	3	4	5	6	7	8	9	10	11
Session I	41	84	110	115	118	108	89	80	64	41	30
Session II	36	83	108	124	118	110	91	82	64	40	24
Series A, Total	36	80	108	116	118	110	91	82	64	44	31
Series B, Total	41	87	110	123	118	108	89	80	64	37	23
Females	41	114	126	133	116	102	79	69	53	29	18
Males	36	53	92	106	120	116	101	93	75	52	36
Total	77	167	218	239	236	218	180	162	128	81	54

TABLE 3

PERCENTAGES "GREATER DEPTH" FOR EACH ILLUMINATION LEVEL FOR SESSIONS, SERIES, AND SEX

EIGHT SUBJECTS

	Illumination Levels										
	1	2	3	4	5	6	7	8	9	10	11
Session I	25.6	52.5	68.8	71.9	73.7	67.6	55.6	50.0	40.0	25.6	18.8
Session II	22.5	51.9	67.6	77.5	73.7	68.8	56.9	51.2	40.0	25.0	15.0
Series A, Total	22.5	50.0	68.6	72.5	73.7	68.8	56.9	51.2	40.0	27.5	19.4
Series B, Total	25.6	54.4	68.8	76.9	73.7	67.6	55.6	50.0	40.0	23.1	14.4
Females	25.6	71.2	78.8	83.0	72.5	63.7	49.4	43.8	33.1	18.2	10.6
Males	22.5	33.1	57.5	72.5	75.0	72.5	63.1	57.5	46.9	32.5	23.1
Total	24.0	52.2	68.1	74.7	73.7	68.1	56.2	50.6	40.0	25.3	16.9

TABLE 4

APPROXIMATE THRESHOLDS OF PERCEPTION IN VOLTS INPUT TO ILLUMINATION SOURCE

	Session I	Session II	Mean
S_1	10.5	10.5	10.50
S_2	10.0	10.5	10.25
S_3	11.0	12.0	11.50
S_4	11.0	12.0	11.50
S_5	10.5	10.0	10.25
S_6	9.7	11.0	10.35
S_7	11.0	11.0	11.0
S_8	10.5	10.0	10.25
Mean	10.53	10.87	10.70

Table 5 lists the area used by each subject in making his judgments and the content of his perception of that area.

TABLE 5

AREA AND PERCEPTS REPORTED

Subject	Session	Area of Ink Blot Used	Percepts Reported in Ink Blot
S_1	I	Top 1/3	When dark it looks like two things. It looks like a tyrant--kind of a monster--and like two freakish kings, sitting back to back on a throne. When bright, it looks like a dead cat, spread out.
	II	Top 1/2 except topmost details	Public baths--two men sitting with a partition between them. When the light is dim, it looks like a wagon--a covered wagon, without a top. Also, could be a boat. Also, same things as before.
S_2	I	Whole blot, mostly	At first, it looked like a tiger skin rug. Later, like a chick in the embryo stage--that was in the middle--the streak in the middle with the light part around it.
	II	Center half	Same as before--a tiger rug and chick embryo.
S_3	I	Middle section --gives a rounded effect	Sometimes at real low illumination it looked like a kettle--just a black image. The top looked like a butterfly.
	II	Middle section	Looked like teeth at the bottom, when it was bright. Two little dots look like eyes. Things

TABLE 5--Continued

			out at the side, man with a mustache. Middle part, lungs. Didn't pay much attention to it at low illumination.
S_4	I	Lower portion of middle section	None
	II	All except top details	Sort of like a cat, at high illumination.
S_5	I	Lower half of top details	At the top it looked round, like an insect. Center looked like the chest part of the human body.
	II	Lower half of top details	Could be the same things, or two sides of a map. The top part, a snake's head. Top of a big jar at the bottom. The chest has a ridge in it.
S_6	I	Middle Part	From geology, it reminded me of a fusilan. Made me think of the anomal inside it. Looks like a priest spreading his hands in supplication. A holy man. Comes from Religious Emphasis Week, I guess. He's pleading--has an ermine, big ermine robe. Also, looked similar to a turtle.
	II	Middle, mostly	A man with hair, long flowing robe, standing under figurines. Two doves--arms out in supplication, like when man comes up and sees home and says "it's mine." What I said was ermine the

TABLE 5--Continued

			other day looks like something flowing out and over his shoulders.
S_7	I	Center section	Reminded me of geological diagrams. Mountains and streams. Geological graphs. When darker, it looked like a dark pattern.
	II	Center, compared with lighter edge	Same as last, except that I judge more on looking through something. Geographical things.
S_8	I	Whole thing. Shadows toward center	Didn't look like much--maybe a bearskin rug. I was paying attention to the depth.
	II	Shadows toward center and sides	I didn't look at it to see anything.

Analysis of Results

A number of questions may be asked concerning this data in order to test the hypotheses set up in this experiment and in order to develop some logical explanation of these results. The first question to be dealt with comes from the first hypothesis to the effect that depth effect varies with change of illumination. Three sources of information may be used to deal with this question. First, the subjective impression of subjects, as seen in Table 6. Each of the eight subjects reports that depth effect varies, according to their experience in the experiment. Second, examination of the judgments of the individual subjects in the experimental situation reveals that in each case there is some pattern of more or less consistent variation of depth effect with change of illumination. Third, the total data may be studied statistically to test this hypothesis. A chi square analysis of variance by ranks (22) was set up with illumination levels as columns and subjects as rows. The chi square value obtained is 38. According to Moses (14, p. 131) this statistic is distributed in a form essentially equivalent to that of chi square when evaluated at p minus 1 degree of freedom. Evaluation of this value at 10 d.f. indicates that there is significant variation in rankings of "greater depth" between illumination levels at the .001 level of significance.

Question two deals with the second hypothesis.

TABLE 6

SUBJECTS' COMMENTS CONCERNING DEPTH VARIATION

Subject	Comments
S_1	It's hard to tell depth--even when it's darkest. The darker it is the harder it is to tell when something's flat. Generally, when the light was from behind it, it appeared to have depth. The darker it is, the more the light seems to be reflected from behind the picture, and it has more depth.
S_2	The darker one has the most depth, except when it's so dark you can't see it. Much greater depth when it's dark. Below the greatest depth, it's just a dark spot.
S_3	Sometimes it's hard to make the judgment. Sometimes when the light was low, I'd look at it and think that I was imagining it. That worried me a little bit--at real low illumination and relatively high illumination. At times, I could see it just as a whole--a black splotch. The trouble occurred just above that point. The lower the illumination, the more it stood out. When the illumination was high--flat--had no depth. Very low, just a black figure.
S_4	I depended on the background light. If it was very light, it doesn't have much depth. It's flat when very dark.
S_5	The more light, the more I could tell it was just something painted there. When it was dark, it seemed like more depth to me. Center sometimes looked curved in. When you see it, you get it in your mind that it has depth--it changes sudden, and the depth doesn't seem to change--you see it anyway, even though it isn't there. At low illumination, it's different. It's one thing--a starfish--round. Medium illumination, it changes--not any one thing.
S_6	Makes me think of radar--similar to a night watch. I thought maybe I could pick out depth because of practice on night watch. I was used to doing that--or was. When you say depth, I think of farther away

TABLE 6--Continued

Subject	Comments
	and a feeling of convexity. (Demonstrates with hands.) At low illumination, it's farther away--curved. At high illumination it's close and is two dimensional. The white part is smoke or something coming out.
S_7	Trouble in making some judgments. On some, the pattern gets closer or farther away, but want <u>in</u> the pattern, don't you? (Tended to be very unsure of judgments.) When it was dark, it was like looking through something--when it was light--geographical things. Dark, like looking through a small crevice. Bright--a hill or a mountain. The depth varies. When it was dark it is deeper. Too dark, you can't judge. When it is bright it is hard to judge. Darker color, more depth. Lighter color at high illumination.
S_8	(Very cautious.) Up 'till the light gets so bright, the depth gets greater. One a little bit dimmer than the brightest one gave the greatest depth. At night, I can't judge distances as easily as in daytime. The logical thing would be to see more depth when it's dark. I see more depth when it's light than when it's dark. My girl friend told me that she sees it the other way--but I can't help it, that's the way I see it. Am I a special case? I hope to be a doctor, but do you think this would stand in my way? Several people in my family have hereditary night blindness--maybe that's what does it.

According to the second hypothesis, depth effect increases to a maximum and then decreases if one varies illumination from a low to a high level. Four sources of information are available which are pertinent to this question. First, the comments of individual subjects when asked to describe their

experiences may be considered. These comments are not particularly illuminating beyond indicating that most people seemed to feel that there is greater depth at the lower illumination levels, and some feel that at certain levels "it's too dark to tell." The second source is the relative percentages "greater depth" for the different illumination levels as given in the individual's judgments. Seven subjects judged depth to increase with increasing illumination to a maximum point and then decrease continuously as illumination is further increased. The other subject (S_6) did not follow this pattern during session I, but did so in both series of session II. Further, mean judgments do follow this pattern. The third source of information is the total percentage greater depth as reported in Table 3. Increase in depth effect is evident at medium illumination levels, with a maximum occuring at level four. At higher illumination levels, decrease in depth effect is evident, with the least depth appearing at the highest illumination level.

Fourth, we may consider these results from a statistical point of view. As has been noted, the "average" data do follow the pattern predicted by the hypothesis. The question may be asked, "Which illumination levels are significantly different from the average maximum point, and in what direction do they very?" To answer this question, a non-parametric paired comparisons test described by Wilcoxen (22) is applied. A separate test has been run for each

illumination level and the results are reported in Table 7. Columns for each test were the total number of "greater depth" responses for each subject at the average maximum level (level four). Rows were subjects.

TABLE 7

SIGNIFICANCE OF VARIATION IN DEPTH EFFECT COMPARED TO LEVEL FOUR

Illumination Level	Lowest Signed Ranks Total	Probability
1	minus 2	.02
2	minus 8.5	not significant
3	minus 12.5	not significant
5	minus 16.5	not significant
6	minus 10.0	not significant
7	minus 6	not significant
8	minus 8	not significant
9	minus 4	.05
10	minus 1	.02
11	minus 1	.02

According to these results, responses at levels 1, 9, 10 and 11 are all significantly less in "depth effect" than the responses at the average maximum depth level.

Further questions may be asked concerning the possible error entering into this data. First, one may query, "Is there significant difference between the responses given in the two different sessions?" To determine the answer to this question, the total responses at each of the

illumination levels for session I are tested against total responses at each level for session II by use of the chi square test (5, p. 189). This test results in a chi square value of 1.76. At 10 d.f., this value is much smaller than the .05 level of significance (18.31), so there is not sufficient evidence to prove that differences are present.

Second, one may ask, "Are there differences between the two series?" To answer this question, the chi square test is applied to the total responses for series A at each illumination level as compared to total responses for series B at each illumination level. This analysis results in a figure of 2.56. No significant evidence of difference is shown by this value when it is evaluated at 10 d.f.

If one examines the data obtained from individuals, it appears that there is an excellent probability that significant sex differences are present. The same suggestion is found in the total data for the four females as compared to total data for the males. A chi square test of this is not possible, since the two sets of data are incompletely correlated. The non-parametric test of paired comparisons was applied, but insignificant differences were found. The least signed ranks total is plus 27, which is not significant.

Individual differences and maximum depth. Superficial examination of the data by individuals reveals that there are considerable apparent differences between these

individuals. The difference would appear to be most significant in the levels at which the maximum depth effects occurred. As was stated in the discussion of the preliminary experiments, this would be expected. In order to explain the results of the experiment effectively and in order to obtain the most significant information from these results, it seemed necessary that the data concerning maximums or "greatest depth point" be analyzed.

These data were derived by listing the illumination levels at which the largest number of greater depth responses occurred. They may be found in Table 8.

The first question to be considered is, "Are there differences between individuals?" To answer this question, the four maximums obtained from the results of each individual are listed as rows with series as columns. The chi square analysis of variance rank test is applied with a result of $Chi_r^2 = 25$. With seven degrees of freedom, this is significant at the .01 level, indicating that there is less difference within an individual's responses than there is between the responses of several individuals.

Examination of the data also indicates that this is true. In most instances, subjects were highly consistent in their maximum depth levels, with differences of zero occurring in some instances. The largest difference within an individual's responses is quite small compared to differences occurring between individuals, where average maximum

TABLE 8

ILLUMINATION LEVELS HAVING THE LARGEST NUMBER OF "GREATER DEPTH" RESPONSES FOR EACH SERIES (MAXIMUMS)

	Subjects							
	Females				Males			
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
Session I								
Series A	2	2	3	4	5	1	3	8
Series B	2.5	2	4	5	5	1	5	8
Mean	2.25	2	3.5	4.5	5	1	4	8
Session II								
Series A	2	2	4	5	5	2	4	7.5
Series B	2	3	3	5	5	3	4	8.5
Mean	2	2.5	3.5	5	5	2.5	4	8
Total Mean	2.125	2.25	3.5	4.725	5	1.75	4	8
Total A Mean	2	2	3.5	4.5	5	1.5	3.5	7.5
Total B Mean	2.25	2.5	3.5	5	5	2	4.5	8.25

levels scatter from level 1 to level 8.

Reversing the rows-columns relationship found in the just previous test, it is possible to evaluate the significance of differences between the four different series. Series are listed as columns and individuals are listed as rows. The Chi_r^2 for this arrangement is 4.2. Evaluated at 3 d.f., the significance level is between .20 and .30, suggesting that the four series are not significantly

different.

Since this test is only a rough approximation, and since examination of the data suggests the possibility of differences, a further test seemed necessary. An attempt was made to evaluate the significance of differences between average maximums for session I as compared to session II by use of the paired replicates test. However, since there are four zero differences and since zero differences cannot be used in this statistic, the results cannot be evaluated. The small differences which do appear would suggest that there is no significant difference between sessions.

The same test has been applied to the possible differences between Total A series maximums, and Total B series maximums. The results in this case are that a least total of signed ranks equal to zero is obtained, which is theoretically significant at the .05 level. However, if one inspects the data it will be found that there are two zero differences which must be ignored in using the statistic. Exclusion of these zero differences probably results in a bias in the direction of significant difference, so there is reason to question the validity of this .05 significance level. There does seem to be a possibility of some difference in the average maximum level between total series A and total series B.

Sex differences also appear as a possibility. Three females' maximums fall below the average median and three

males' maximums fall above the average median. However, the mumbers involved are too small to be evaluated effectively.

A further question about the maximum points comes from some of the preliminary work. The question is, "Is there any relationship between the threshold of perception of the ink blot and the maximum depth level?" To facilitate an estimation of the answer to this question, approximate thresholds of perception were obtained for each subject in each experimental session (Table 4). The rank correlation method (5, p. 260) was used to evaluate the significance of what appeared to be a relationship between ranked thresholds of perception and ranked maximum depth levels.

TABLE 9

RANK CORRELATION COEFFICIENTS FOR MAXIMUMS COMPARED TO THRESHOLDS OF PERCEPTION, EIGHT SUBJECTS

Variables	r_s	Significance*
Session I maximums and Session I thresholds	.52	Not significant
Session II maximums and Session II thresholds	-.071	Not significant
Average maximums and average thresholds	-.065	Not significant

*(5, p. 261)

The resulting r_s values are listed in Table 9. No significant correlation was found, so it must be concluded

that there is no evidence for a maximum level and threshold of perception.

Summary of the Analysis of Results

Concerning the general questions raised by the original hypotheses, statistical evaluation demonstrates that significant variation in depth effect reaches a maximum and then decreases. No significant differences were found between sessions, series, or sexes.

From study of the maximum levels, significant differences were found between individual's maximums, but no significant differences occurred within the four maximums obtained. The differences between sessions could not be evaluated statistically, but inspection of the data suggests that no significant differences between sessions are present. Statistically significant differences were found between series A maximums and series B maximums. However, the differences were small and the two zero differences that appeared in the data must be ignored due to limitations of the statistical method; so this significant difference may be spurious. A possibility of sex differences was observed, although statistical analysis of these differences was not possible.

Finally, no significant relationship was found between the maximum level and the threshold of perception.

CHAPTER V

DISCUSSION

To summarize and delineate, the variables of the problem are:

1. The experimental stimulus is an ink blot (Plate VI of the Rorschach Test). The stimulus has definite shape and was observed in each comparison from a constant distance with a relatively constant angle of vision. The blot is relatively unstructured and, of course, was not designed to represent any particular object or thing. The stimuli arising from the blot may be organized in many different ways and, conceivably, each organization can have a large number of different "meanings." Thus, the meaning of the ink blot can be considered variable with the one exception that most people, under ordinary circumstances, would consider it an ink blot.

Within the blot itself there is considerable variation in dark and light, or gray and black, shadings. This variation is gradual in some parts of the blot, but the gradation is sharp in other parts. There is also considerable variation in texture and fineness of detail within the

blot. Several markings are present which might be considered as converging lines.

2. The blot is presented under essentially constant conditions with the exception of one significant variable. Intensity of illumination is varied systematically within the limits of .018 foot candles and 5.7 foot candles reflected light.

3. Subjects judged the relative depth effect within this range of illumination and it was found that variation of apparent depth occurred according to a function which reaches a maximum below the maximum of illumination.

Variation in meaning of the ink blot was also reported by some subjects. In those instances in which variation in meaning was clearly reported such variation appeared to be a function of the level of illumination. This variable was not rigorously investigated in the experiment and this observation must necessarily be considered as tentative.

At the most concrete level, these are the variables of the experiment. In order to explain the results, a theoretical explanation should be developed from perception theory which encompasses both variables and results.

First, it seems clear that apparent depth effect is somehow a function of the perception of the stimulus material by the subject. Since the blot is flat and has no actual depth and no specific meaning beyond that of ink blot, any depth perceived or any special meaning assigned to the

blot appears attributable to the perceiver. Since subjects were given the task of judging relative depth effect within the ink blot, a set to "see depth" was established. However, it can be assumed that the fact that depth was reported is due to more than the task set. Since depth is often reported in this plate in the conventional Rorschach test results, it is assumed that there is something about the plate itself which tends to produce the impression of depth.

Existing theories of depth perception traditionally consider the phenomenon to be a function of particular visual cues. Certain depth cues do seem to be present in the ink blot. According to Woodworth (23), the Renaissance painters became concerned about this problem because they had difficulty in producing good depth effect in their paintings. Leonardo da Vinci precisely analyzed and stated the variables which seemed to be involved in depth perception at that time. According to Woodworth:

> Leonardo found that depth was revealed largely by light and shadow. He distinguished attached shadow from the more obvious cast shadow. The shadow of one object is cast on another object, as a man's shadow is cast on the ground. The shadow of an object appears attached to that same object. The shading of a face, due to the way the light strikes certain parts more than others, appears to be on the face. Attached shadows show the real life or three dimensional shape of a single object, while cast shadows reveal spatial relationships between objects (23, p. 651).

Following this reasoning, he pointed up a series of depth cues, and demonstrated the existence of retinal

disparity as an important factor in depth perception. Since da Vinci many experimentalists and theorists have tackled the problem of depth perception (6, pp. 138-144; 8, pp. 870-887; 16, pp. 177-204; 21, p. 93; 23, pp. 651-680). Present day theories differentiate the "depth cues" into two general classes. These are monocular and binocular cues. Attempting to integrate the above theorists, two significant types of binocular cues can be assumed: retinal disparity cues and convergence cues. The usual list of monocular cues includes the following: linear perspective, detail perspective, aerial perspective, light and shadow, movement perspective, interposition of objects, and accomodation.

Since no controls were introduced in the experiment to limit the cues to be used by the subject in his judgments, it would be impossible specifically to include or eliminate which cues were used by a given subject. Inspection of the ink blot suggests that the following cues, or some combination of them, might have been operant: detail perspective, from the variation of texture and fineness of detail; light and shadow, from the dark and light shadings which are present; and linear perspective, from what could have been considered converging lines. Without controlled experimentation to determine the presence or absence of other possible cues, no statement could be made about their applicability. For the purposes of this discussion, it seems established that certain visual depth cues are present in the perceptual

situation and that there is some basis within the ink blot for the perception of apparent depth.

If it were possible to make a complete and accurate statement of the cues employed in the perception of apparent depth, and if complete data were available concerning the effect of the variation of illumination on each of these cues, a logical, theoretical explanation of the results might be developed at this point. Since this cannot be done, another approach seems necessary; in fact no simple assumption about the effects of illumination change seems to suffice.

If the visual cues which are the stimuli for apparent depth were simple functions of the degree of visual acuity, a satisfactory solution of the problem should be easily obtained. Visual acuity increases according to a sigmoid relationship with increasing illumination (16, p. 131), so little or no depth from visual cues at or near the threshold illumination values would be expected. This concurs with the empirical results. As illumination is increased, visual acuity increases and it should be possible to see the depth cues more clearly, thus resulting in greater depth effect. This also appears to be valid. As illumination is increased further, the depth cues should become completely clear and a maximum depth point should be reached at a relatively low illumination level. This appears to be valid. However, one would expect the cues to

have relatively constant effect throughout the range of normal illumination and the depth effect should remain relatively constant. At this point the simple explanation breaks down since the depth effect is found to decrease as illumination is increased above the maximum depth point.

A further argument against the simple explanation is to be found in the significance levels of the correlation between thresholds of perception and maximum depth levels. If the depth effect is a simple function of visual acuity, the thresholds of perception of the ink blot would be expected to correlate roughly with the point of maximum distinctness of depth cues, or the maximum depth point. No correlation was found between these two levels, so there would appear to be further reason to doubt that the variation of apparent depth effect is a direct function of the ease of seeing visual depth cues.

A more satisfactory explanation perhaps may be developed by considering these phenomena in the light of the perceptual process itself. To understand the perceptual process which seems to be involved in this experiment, we must first attempt to understand how the subject goes about perceiving depth in the ink blot. It would seem possible to assume that we do not come into the world with the capacity to perceive depth in flat, shaded objects which have variation in detail and texture, although according to Vernon (20, p. 110) certain Gestalt theorists feel that

there is an innate tendency to perceive in terms of three dimensions. However, if a young infant is observed it does not seem that he recognizes the difference between objects which are at different distances within his perceptual field. Eventually, apparently with maturation and experience, the infant can begin to make effective judgments of depth. How he gets to the point of making effective judgments of depth may well involve certain innate tendencies. However, the infant cannot be assumed to evaluate such factors intellectually at this point, and the assumption seems warranted that this skill comes from experience. Piaget (15) has published one study in this area in which he has shown that this skill is not present in the infant and that it develops with maturation and experience in a manner similar to that found in the acquisition of social skills.

Presumably, a child finds that in order to reach a ball of a given shape, size, color, shading, etc., he must move across a room. When it looks different in certain ways, he may simply reach his hand out to get it. In touching and manipulating an object of given shape, he finds that it does have a given shape and is not merely an outline or a flat surface. He learns, by some means, that this sort of shading, texture, shadows, etc., has meaning in terms of shape and distance. This is probably not a conceptualized process but rather a process which occurs in terms of experiences and internal organization of experiences.

How then is it possible for a person to perceive depth in a situation where no real depth is present, such as the Rorschach ink blot? The logical answer seems to be that apparent depth is perceived by virtue of an internal organization of past experiences which have indicated that objects which are shaded in this way, and have these changes in shading and texture, are objects which <u>have depth</u>. On this basis, then, it can be contended that apparent depth perceived in a situation such as this experiment is a function of internal factors and may be classified as a "projective phenomenon."

Sherif (18, p. 225) has developed from gestalt psychology a model for perception which is useful in terms of this context. According to Sherif, perception is the end product of the interaction of both internal and external factors; the organization which results from this interaction is the perception. He further suggests that any reduction in the external factors will result in greater influence of the internal factors upon perception, and vice versa. The problem under consideration involves some such perceptual process. Initially, we have a relatively equivocal stimulus. In the experiment, illumination has been varied, and in varying the illumination, we have changed the degree of external stimulation. When illumination is reduced the ink blot becomes more equivocal. When the illumination is increased the ink blot is still unstructured but

is probably more structured than before since visual acuity has increased, and the subject can "see it better."

Now, if apparent depth is a function of internal factors in this situation, and by varying the illumination we have changed the degree of stimulation from external factors, one would expect that depth effect would increase with decreasing illumination and decrease with increasing illumination. The results of the experiment demonstrate that this is true empirically, down to an individually determined maximum point.

The foregoing is considered as a general explanation of the results obtained at the higher levels of illumination used. Another explanation must be developed for the results obtained at the lower levels.

In discussing the portion of the curve in which depth effect decreases with decrease in illumination and increases with increase in illumination, two different possible explanations seem applicable. From the point of view of the visual factors involved, there is a point in the reduction of illumination where an object, or an ink blot, begins to be hard to see. This would be expected in terms of the curve of visual acuity versus illumination, and one might say that all of the visual cues which are contributing to the depth effect have been reduced or changed to such a degree that they are no longer effective at all, and there is no adequate basis on which to see depth. Thus, the depth

effect decreases after having reached a maximum.

However, if this rationale is completely accurate, one would expect some correlation between the lower threshold of perception of the ink blot and the maximum level. As has already been discussed, no correlation was found between these two variables.

Taking the problem from the point of view of the perceptual processes involved, apparent depth can be considered a projective phenomenon. From clinical experience it is known that a certain minimum of external structure or external "materials to be organized" is necessary for the production of responses by clients in a diagnostic situation. When a client looks at a TAT card he sees some structure, in that a scene is depicted. However, the mood, the activity, and the content of the picture are left equivocal and subject to interpretation, "misinterpretation," or projection. When he is given the blank card which is No. 16 in the series, there are no external cues, and most people cannot give a story to this card. They simply say "It's a blank card." Projection is apparently very difficult because no external basis exists on which to project. A certain minimum degree of such external basis does seem, for most people, to be necessary in a projective technique in order for the instrument to be useful.

In this experiment, an analogous situation is present. In the case of reduction of illumination, the

intensity of external stimulation has been reduced, bringing internal factors to the fore and producing a greater relative degree of projection of depth. However, a point is reached beyond which the subject feels that he has no adequate basis on which to project "depth" and on a more or less unconscious basis stops projecting. At a subjective level, this has been verbalized by many subjects as a "feeling of threat" or insecurity, and many subjects have been observed to become tense at low illumination levels, both in terms of physical posture and pitch of the voice.

In terms of this analysis of the problem, we may say that the subject has reached the "limits of projection." He finds it necessary to fall back on his defenses against projection and to perceive less depth as illumination is decreased further. In this case, the defense involves regression in the direction of the "real nature of the blot," that is, a flat card with no depth. If this experiment does involve projection, and if it has been demonstrated that there is a maximum point for projection at relatively low levels of external stimulation, then we would expect large individual differences, at least from a clinical point of view. Some people are apparently free to project, others project unconsciously, and still others will not permit themselves to project, relying constantly on the defense of sticking to immediate reality. Some people "freeze up" when given a Rorschach card or when placed in any

unstructured situation, others are quite productive. Individual differences were found in the study of the maximum levels, so some support is lent to the notion that these results can perhaps best be explained in a projective framework.

Subjects' organization or meaning assigned to the blot would seem likely also to vary with illumination if this rationale holds. No tightly controlled experimentation has been done to test such a possibility but there seems to be evidence to support this inference. In the preliminary experiments an "open" structure was given and subjects consistently reported simple form-determined percepts of a relatively common variety near the lower threshold of perception. As illumination was increased, the content of the reported percepts often involved materials which could be classified as "deep level, unconscious materials" in the psychoanalytic sense. When illumination was high the meaning most given was "ink blot--it doesn't look like anything but an ink blot." This would seem to follow the same pattern as the apparent depth effect, since minimal projection would be involved in the simple, form-determined percept, a great deal of projection would be involved in the "deep level unconsciously determined percepts," and essentially no projection in the perception of the ink blot as an "ink blot."

In summary, theoretical analysis of the problem

involved in this experiment and comparison of theory and empirical facts result in the conclusion that variation of depth effect which occurs when illumination is varied comes about as a result of change in perceived structure of the ink blot, change which is associated with variation of illumination. At extremely low levels of illumination, insufficient structure for depth is present due to poor visibility of the blot. As illumination is increased slightly above these lowest illumination levels, the depth cues become more apparent and the blot becomes structured to a degree which makes possible the projection of depth effect. As illumination is further increased, the depth effect increases until the structure becomes too great for effective projection. Then, less depth is seen as illumination is further increased because the structure is increasing as illumination is increased. The maximum depth point which appears seems to be determined by the individual's internal need for structure. At this maximum level, dominance appears to shift from structuredness to visibility and a reversal of the direction of change of depth effect occurs.

Implications for Perception

There are several important implications for perception theory and experimentation which can be drawn from these results and this theoretical analysis. First it seems clear that analysis in terms of what is known about the

visual cues involved does not adequately explain the results. The stimulus variables do not seem to operate as a simple function of visual acuity; rather the apparent depth perception in this setting seems to be more easily explained as a function of the total perceptual situation rather than of absolute stimulus cues of given values. Analysis of this particular depth perception situation seems to yield the most satisfactory understanding in terms of the total perceptual process related to more general concepts of perceptual theory.

In view of this observation there may be some basis for raising further questions concerning depth perception. Since depth perception is probably a function of the organization of experience, and since people organize experience in many different ways, how can it be known that the conventional depth cues are used in the same way by all people? It is possible that such cues have quite different meanings and importance to different individuals. This would certainly seem to be likely in the case of apparent depth perception and may also be true in terms of real depth perception.

Two concrete instances may serve to open the question further for consideration. Artists make extensive use of the conventional depth cues in bringing depth into their paintings. However, if one asks a number of people to describe their reactions to a painting it would seem that

for some the painting appears to have life and depth, and for others it is meaningless and flat. A colleague of the author commented on this recently. He pointed out that he never has the experience of depth in observing paintings, nor, for that matter, does he experience depth in the conventional Rorschach situation. The Rorschach provides us with further reason for asking questions of depth perception theory. Since depth effects are considered as "determinants" for certain Rorschach perceptions, there is a considerable body of clinical evidence which may be used to evaluate at least one aspect of apparent depth perception. Some people report "depth" in the gray-black Rorschach ink blots and others do not. This is an empirical fact, and yet if one considers the Rorschach in terms of depth cues, the depth cues are present for every person who looks at these Rorschach blots. Evidently people respond quite differently to identical "depth cue" stimulus situations.

An intriguing, concrete problem appears as a further implication of these experimental results. In this situation, a relatively unstructured stimulus was used which was not in any way deliberately designed to produce depth effects or to portray any particular object. What would one expect to find if the stimulus was changed to represent some specific object with deliberate depth cues added? The theoretical probabilities could be debated extensively, but the author tried it out with interesting, although not

experimentally verified results. A picture of a completely empty room was obtained. A skillful artist had designed and inlaid the walls of this room with mosaic to represent furniture, books, desks, lamps, etc., in depth. Even after one finds that the objects in the room are only simulated, the room continues to appear as full of furniture. This picture was placed in the box, at the same distance as the original Rorschach card stimulus. Several subjects performed in a procedure similar to that of the experiment described in this research. The first two subjects saw the depth effect vary up to a maximum which was at a much higher illumination level than the maximum found when the Rorschach blot was used. These same two subjects saw "apparent depth" in the Rorschach blot in the same general manner as did the experimental subjects. However, two other subjects saw the maximum depth at about the same illumination level as they did in the case of the Rorschach blot. In the case of the first two individuals, the additional "depth cues" resulted in a quite different maximum depth level than was found in the case of the Rorschach blot. For the other two subjects, these additional depth cues apparently made no difference in the maximum depth level that was perceived as compared to the maximum seen in the Rorschach blot. More extensive, controlled experimentation would, of course, be necessary to demonstrate that such drastic differences in the use of "depth cues" exist.

Implications for Rorschach and Projective Theory

From the results of this research at least two important hypotheses may be set up which have to do with the Rorschach and projective testing.

This experiment has demonstrated that depth effects in the Rorschach card vary according to illumination intensity. These results have been interpreted in terms of a "projective" concept, and it appears that maximum projection does occur at a relatively low illumination intensity. For the subjects tested in this experiment, the range of "maximum depth effect," and, theoretically, maximum projection, was from .032 foot candles reflected light to .57 foot candles.

From the fact that depth effect varies according to illumination intensity, it seems that a hypothesis might be set up to the effect that "In order to obtain a standardized perceptual situation in the use of the Rorschach, illumination intensity must be standardized." Standardization of such salient variables as the Rorschach blots themselves, instructions prior to the test, procedure of the test, and the gaining of maximum rapport with clients are all considered to be essentials for adequate Rorschach testing. However, illumination has not been considered as important by some Rorschach theorists, while others have specifically emphasized that it must be standardized.

For example, Beck states that "whether the lighting

is daylight or artificial does not appear to matter. I have found it necessary to use either, without any observable effect on the results" (2, p. 3). Rorschach (17) does not mention the problem of illumination but does state several other situational factors which may influence the results. For example, he has found that distance of the card from the subject is important and warns Rorschach administrators to prevent the possibility of the subject's seeing the card at a greater distance than an arm's length (17, p. 16). Klopfer and Kelly state that "the actual lighting conditions during administration play a very insignificant role" (10, p. 14). Bochner and Halpern state that "the best results are obtained if the test if given in daylight, since artificial light alters the effect produced by color and shading. However, tests so obtained are not necessarily invalid" (3, p. 1). Mons specifically states that the type of illumination is important. He states that "the light should be good without being glarey or sunny. Artificial light changes the color effects and is therefore unsuitable. A good quality daylight lamp can be used if necessary" (13, p. 24).

Thus, there seems to be considerable disagreement among Rorschach theorists. There is no experimental evidence in the literature concerning the effects of illumination upon Rorschach determinants or content, so the question is clearly open for speculation and further study.

The second hypothesis which may be set up concerning the Rorschach is that "Illumination intensity should be relatively low in the Rorschach testing situation in order to obtain the maximum extent of projection." In terms of the "projective concept" used in interpreting the experimental results, it seems necessary that we conclude that greater projection of depth effects occurs under low illumination as compared to high illumination. This, in itself, would not be sufficient to suggest that illumination should be low in the Rorschach situation, since many "determinants" other than depth are involved in an analysis of the Rorschach protocol. However, according to the preliminary experiments, and according to the results from several subjects in the final experiments, the content of Rorschach perception varies with variation in illumination. The sort of variation that seems to occur suggests that deeper level, unconsciously determined percepts are seen in the Rorschach blot at the illumination levels associated with the "maximum depth point." A completely different organization may occur at another level of illumination, and most subjects see nothing but "an ink blot" at high illumination.

Necessarily, since illumination has not been considered important by the two most popular American Rorschach theorists, Beck and Klopfer, illumination is not controlled in present day Rorschach administration. To check on the actual illumination found in Rorschach situations at the

Psychological Service Center, University of Oklahoma, a GE light meter was used to measure the light reflected from the card in three different testing situations. In the author's office, with the desk lamp on, the reflected light was slightly below one foot candle. With the ceiling lights on, it was one-and-a-half to two foot candles, depending on the angle of the card. In another office, which has large windows, the reflected light was about four foot candles. If one examines the curves of the relative depth effects for the experimental subjects for these three illumination levels, it is immediately apparent that quite different depth effects for each of these situations would be expected. One would also suspect that the content of percepts would be different in certain qualitative and perhaps quantitative ways. The empirical effects of illumination level upon perception in the case of actual Rorschach administration can be tested experimentally. A check of these hypotheses would involve a number of restrictions that might not be necessary in conventional experimentation. Rorschach tests could not be repeated under differing illumination conditions with the same subjects, since clinical experience suggests that the organization of the Rorschach materials is "perceptually set" by the first experience with the blots. One possible method of attacking the problem might be to give a large number of Rorschachs to randomly selected individuals under several different illumination conditions.

For example, if the population included 150 subjects, perhaps one-third could be given the Rorschach with five foot candles illumination, one-third with two foot candles illumination, and one-third with one-half foot candle illumination. Some such procedure might produce data which could be qualitatively and quantitatively compared to determine differences in content, determinants, and subjective factors between the different illumination levels.

CHAPTER VI

SUMMARY

From the statement that the perception of the Rorschach ink blot involves aspects of perception which have not been adequately explained by present perception theory, it was felt that new facts might be obtained from the experimental study of the perception of the Rorschach ink blot. On the basis of exploratory experiments in which the illumination of the ink blots was varied, the following hypotheses were obtained:

1. Depth effect in the Rorschach ink blot varies as a function of change in illumination.

2. With changes in illumination, the depth effect changes according to a function which reaches a maximum and then decreases.

The psychophysical method of paired comparisons was employed to test the depth effect seen by eight naive subjects. Statistical analysis of the data tended to support both hypotheses. It was found also that there are large individual differences in the maximum depth level of illumination.

The results could not be explained adequately in terms of an assumption that the depth effect is a single function of visual cues and variations in visual acuity, and therefore more general concepts of the total perceptual process were used to explain the results. It was concluded that the apparent depth effects perceived in the blots occur as a function of three variables, or classes of variables. These are: variation in the structuredness of the ink blot, such structuredness varying as a function of the level of illumination; visibility, varying as a function of the illumination level; and the subject's need for structure, determined by the individual's internal stresses. Variation in structuredness accounts for the inverse relation of depth effect to illumination in the higher levels of illumination, while visibility accounts for the direct relation of depth effect to illumination in the lower ranges of illumination. The level of maximum depth point appears to be determined by the individual's need for structure; and at this maximum point, dominance shifts from structuredness to visibility as the determining variable.

The traditional conception of depth perception as a function of depth cues alone was questioned and the need for further research in the area of depth perception theory was emphasized. At the level of practical application, the results suggest that illumination should be controlled to get consistent results from Rorschach administration and

that a particular level of illumination may be most satisfactory in getting the most significant responses to the ink blots.

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APPENDIX I

SAMPLES OF THE DATA OBTAINED IN THE PRELIMINARY EXPERIMENTS

PRELIMINARY SUBJECT L (NAIVE) 18 YEAR OLD MALE, FRESHMAN

Plate I, Rorschach

Illumination	Response
19 volts	Seems to be a wolf's head kinda back in the haze.
21 volts	Looks like a couple of collies back to back, long nose and pointed ears.
30 volts	Kinda get the idea of sea horses.
48 volts	In the middle, see a woman from the waist down to knees. Can almost see her belt buckle--light spot in the middle.
60 volts	Ink blot.
90 volts	Just an ink blot.
130 volts	Just an ink blot.
(Voltage was decreased after this point. No further response given until:)	
22 volts	There's my wolf again. Two sets of eyes, nose and ears. He's back again.
(Comments on depth: The depth gets less and less as the light gets brighter.)	

PRELIMINARY SUBJECT M (NAIVE)
18½ YEAR OLD MALE, FRESHMAN

Plate II, Rorschach	
Illumination	Response
23 volts	See a design--very faint. Looks like two pregnant women kissing each other. Looks like an umbrella is attached to their heads.
27 volts	Getting lighter.
29 volts	Two little orange designs at the bottom.
50 volts	See it's a design, made with black ink and red ink.
64 volts	Very bright.
81 volts	Background all white.
(Voltage increased to 130, then reduced to:)	
118 volts	Now that it's close, it looks more like two little dogs than the first design did.
90 volts	Getting dimmer now.
50 volts	As it gets dimmer, it looks like it's going away.
40 volts	Very dark.
30 volts	Now, I can just make out the outline.
23 volts	Barely on.
20 volts	Barely see it.
18 volts	It's gone.
Plate III, Rorschach	
21 volts	See a design--looks very dark.
23 volts	It's brighter--top part looks like a man,

	with a sailor cap. Two designs inside, two outside. Can't make them out.
30 volts	Two little black dots inside of the design.
48 volts	Brighter.
83 volts	Very bright--so it's a design again, made by ink.
130 volts	Very, very bright.
44 volts	Getting darker--fading away.
27 volts	Barely see it.
20 volts	Gone.

Plate IV, Rorschach

20 volts	See a design--looks like a bat with the wings open.
30 volts	Getting brighter.
54 volts	Now it looks like a maple leaf, painted right on there.
80 volts	Very bright. It's once again an ink design.
102 volts	Very bright.
130 volts	--
103 volts	Starting to get darker now.
52 volts	Dimmer and dimmer. Looks as though the design is going away from me.
20 volts	Gone.

Plate VIII, Rorschach

22 volts	Design. Can't make it out.
28 volts	Red color on outside. Head of some kind of person from another planet. Mustache, two

	nostrils, the top of the head looks square.
32 volts	Brighter and brighter. Two black lines on top of head.
40 volts	Lighter and clearer. Ink blot again.
50 volts	Lighter. Can see nostrils as yellow ink, mustache as blue ink.
94 volts	Bottom is brown color.

PRELIMINARY SUBJECT N (NAIVE)
22 YEAR OLD MALE, SENIOR

Illumination	Response
Plate III, Rorschach	
19 volts	Two halves of an embryo--a frog, maybe.
22 volts	Two gorillas doing a swan dive off a diving board. Back to each other, though.
34 volts	Red spots in center look like some tropical fish.
(No further report until illumination had been increased to 130 volts, and reduced to 22 volts).	
22 volts	Looks like a monkey faced owl, two eyes staring at you.
Plate IV, Rorschach	
17 volts	Looks like a bat, or maybe a modern airplane with flying wings.
20 volts	An eagle, now.
24 volts	Looks like a lady dancer with a full skirt. Legs crossed like a ballet dancer.
(No further response as illumination was increased to 130 volts and reduced to zero.)	
Plate VI, Rorschach	
19 volts	Looks like a tree. Can just barely see it though.
30 volts	Woman in middle, or a person, standing in the middle.
130 volts	Nothing.
42 volts	Looks like an old English king. Robe down to his knees. His hair way down. Back in Egypt maybe. Or it could be a girl with long hair, and a cloak or train.

PRELIMINARY SUBJECT O (NAIVE)
18 YEAR OLD MALE, FRESHMAN

Plate VI, Rorschach	
Illumination	Response
19 volts	Looks like some kind of tree. Might be a pine tree. Hanging over a cliff, or on the peak of a cliff.
21 volts	A man, or shadow of a man, leaning up against the tree.
32 volts	Looks like some type of rock formation on a mountain.
66 volts	Shadow of a bird flying off the rock.
(No further response during process of increasing to 130 volts and reduction to 29 volts.)	
29 volts	Going back to the pine tree and the cliff.

Plate VIII, Rorschach	
20 volts	Looks like head of some movie strip character--cartoon characters.
27 volts	Looks like an elaborately decorated jug--turned upside down.
90 volts	Can't connect it with anything at this point.
130 volts	--
40 volts	Now, the comic character again. Looks like a Chinese--staring eyes, mustache turned up.
32 volts	Looks like he's smiling--now he's frowning.
28 volts	Now he's smiling again--Chinese expression gone--could be some kind of a hillbilly now --somebody like you'd see in Li'l Abner.

APPENDIX II

APPARATUS

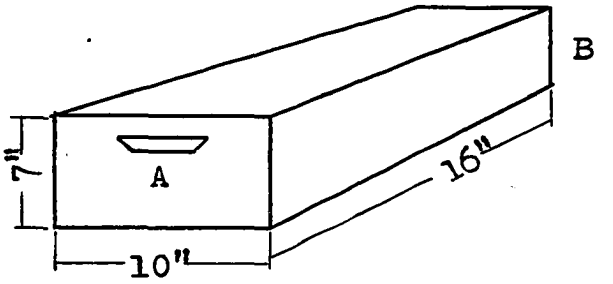

Figure 1. Drawing of apparatus showing outside dimensions

A -- Viewing slot

B -- Position of ink blot

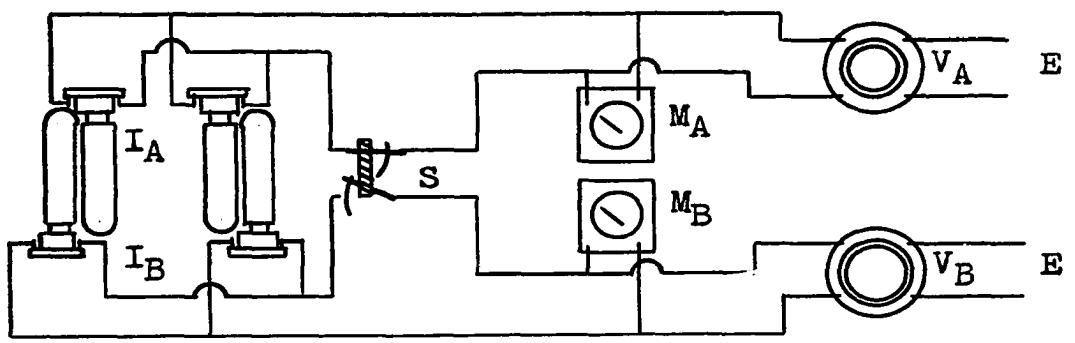

Figure 2. Schematic drawing of electrical circuit.

Circuit A

E	110 volt source
V_A	Variable transformer
M_A	Electronic voltmeter
S	Switch in Circuit A Position
I_A	Illumination source (Pencil type bulbs)

Circuit B

E	110 volt source
V_B	Variable transformer
M_B	Electronic voltmeter
S	Switch open
I_B	Illumination source

APPENDIX III

ILLUMINATION LEVELS IN FOOT CANDLES REFLECTED LIGHT FOR THE GIVEN VOLTAGE SETTINGS

Illumination source: Two 40-watt pencil type bulbs with reflectors.

Measuring instrument: Standard GE photoelectric cell light-meter calibrated in foot candles.

Volts	Foot Candles
40	2
52	4
56	5
68	10
75	15
80	20
85	25
90	30
95	35
98	40
102	45
106	50
109	55
112	60
114	65
116	70
118	75
120	80
122	85
124	90
126	95
128	100

APPENDIX IV

ILLUMINATION IN FOOT CANDLES REFLECTED LIGHT FOR THE ILLUMINATION LEVELS USED IN THE EXPERIMENT

Level	Volts	Illumination
1	11.5	.018
2	13.5	.032
3	15.5	.057
4	18.5	.100
5	22.0	.180
6	25.5	.320
7	30.5	.570
8	35.0	1.000
9	41.0	1.800
10	48.5	3.200
11	57.0	5.700

APPENDIX V

SET OF COMPARISONS USED IN THE FINAL EXPERIMENT

Trial	Voltage Settings*	Trial	Voltage Settings*	Trial	Voltage Settings*
1.	57-35	38.	15.5-30.5	75.	41-48.5
2.	18-30.5	39.	13.5-22	76.	13.5-11.5
3.	30.5-41	40.	30.5-15.5	77.	57-48.5
4.	13.5-48.5	41.	35-18.5	78.	25.5-11.5
5.	35-48.5	42.	41-11.5	79.	48.5-30.5
6.	13.5-30.5	43.	22-18.5	80.	48.5-11.5
7.	48.5-13.5	44.	15.5-57	81.	18.5-15.5
8.	30.5-11.5	45.	25.5-48.5	82.	13.5-57
9.	22-25.5	46.	15.5-13.5	83.	11.5-18.5
10.	15.5-48.5	47.	57-41	84.	22-30.5
11.	57-25.5	48.	57-11.5	85.	35-25.5
12.	18.5-48.5	49.	30.5-18.5	86.	25.5-41
13.	30.5-25.5	50.	41-57	87.	18.5-57
14.	15.5-18.5	51.	15.5-41	88.	35-13.5
15.	35-41	52.	41-13.5	89.	11.5-30.5
16.	22-13.5	53.	18.5-25.5	90.	18.5-13.5
17.	41-15.5	54.	48.5-41	91.	18.5-35
18.	15.5-11.5	55.	41-30.5	92.	35-57
19.	22-15.5	56.	41-18.5	93.	22-35
20.	41-22	57.	11.5-48.5	94.	13.5-15.5
21.	25.5-30.5	58.	41-25.5	95.	22-57
22.	35-22	59.	25.5-35	96.	18.5-22
23.	25.5-57	60.	48.5-25.5	97.	41-35
24.	48.5-15.5	61.	11.5-25.5	98.	18.5-41
25.	11.5-41	62.	48.5-57	99.	13.5-18.5
26.	18.5-11.5	63.	30.5-48.5	100.	13.5-41
27.	15.5-25.5	64.	57-22	101.	11.5-15.5
28.	22-41	65.	30.5-57	102.	57-13.5
29.	15.5-22	66.	57-30.5	103.	13.5-25.5
30.	25.5-15.5	67.	48.5-35	104.	11.5-57
31.	48.5-22	68.	22-48.5	105.	48.5-18.5
32.	57-15.5	69.	30.5-13.5	106.	11.5-13.5
33.	11.5-22	70.	25.5-13.5	107.	35-11.5
34.	11.5-35	71.	30.5-35	108.	25.5-18.5
35.	30.5-22	72.	35-15.5	109.	35-30.5
36.	57-18.5	73.	13.5-35	110.	15.5-35
37.	25.5-22	74.	22-11.5		

*First number in each series is voltage setting for Circuit A; second number in each series is setting for Circuit B. For example, in Trial 1, 57 is the voltage setting for Circuit A, and 35 is setting for Circuit B.

APPENDIX VI

RAW DATA OBTAINED IN FINAL EXPERIMENT

JUDGMENTS OF S_1 --FEMALE

Illumination Level, Circuit A	Illumination Level, Circuit B										
	1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	B*	A*	A	B	B	A	B	B	B	B
2	B	-	B	B	B	B	B	B	B	B	B
3	A	A	-	B	B	B	B	B	B	B	B
4	A	A	B	-	B	B	B	B	B	B	B
5	A	A	A	A	-	B	B	B	B	B	B
6	A	A	A	A	A	-	B	B	B	B	B
7	A	A	A	A	A	A	-	B	B	B	B
8	A	A	A	A	A	A	A	-	B	B	B
9	B	A	A	A	A	A	A	A	-	B	B
10	A	A	A	A	A	A	A	A	A	-	B
11	A	A	A	A	A	A	A	A	A	A	-
	Session II										
1	-	A	A	A	B	B	A	B	B	B	B
2	A	-	B	B	B	B	B	B	B	B	B
3	A	A	-	B	B	B	B	B	B	B	B
4	A	A	A	-	B	B	B	B	B	B	B
5	B	A	A	A	-	B	B	B	B	B	B
6	A	A	A	A	A	-	B	B	B	B	B
7	A	A	A	A	A	A	-	B	B	B	B
8	B	A	A	A	A	A	A	-	B	B	B
9	B	A	A	A	A	A	A	A	-	B	B
10	A	A	A	A	A	A	A	A	A	-	B
11	A	A	A	A	A	A	A	A	A	A	-

*"B" response indicates that the illumination level for the row produces less depth than the illumination level for the column. "A" response indicates that the illumination level for the row produces greater depth than the illumination level for the column.

JUDGMENTS OF S_2 --FEMALE

Illumination Level, Circuit A	Illumination Level, Circuit B										
	1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	B	B	B	B	B	B	B	B	B
3	B	A	-	B	B	B	B	B	B	B	B
4	B	A	A	-	B	B	B	B	B	B	B
5	B	A	A	A	-	B	B	B	B	B	B
6	B	A	A	A	A	-	B	B	B	B	B
7	A	A	B	A	A	A	-	B	B	B	B
8	B	A	A	A	A	A	A	-	B	B	B
9	A	A	A	A	A	A	A	A	-	B	B
10	A	A	A	A	A	A	A	A	A	-	B
11	A	A	A	A	A	A	A	A	A	A	-
	Session II										
1	-	A	A	A	A	A	B	B	A	B	A
2	B	-	A	B	B	B	B	B	B	B	B
3	B	A	-	B	B	B	B	B	B	B	B
4	B	A	A	-	B	B	B	B	B	B	B
5	B	A	A	A	-	B	B	B	B	B	B
6	B	A	A	A	A	-	B	B	B	B	B
7	A	A	A	A	A	A	-	A	B	B	B
8	B	A	A	A	A	A	A	-	B	B	B
9	B	A	A	A	A	A	A	A	-	B	B
10	A	A	A	A	A	A	A	A	A	-	B
11	A	A	A	A	A	A	A	A	A	A	-

JUDGMENTS OF S_3 --FEMALE

Illumination Level, Circuit A	Illumination Level, Circuit B										
	1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	A	A	A	A	A	B	A	B	A	A
2	B	-	B	A	B	B	B	B	B	B	B
3	B	B	-	A	B	B	B	B	B	B	B
4	B	B	A	-	B	B	B	B	B	B	B
5	B	A	A	B	-	B	B	B	B	B	B
6	B	B	A	A	A	-	B	B	B	B	B
7	B	A	A	A	A	A	-	B	B	B	B
8	B	A	A	A	A	A	A	-	B	B	B
9	B	B	A	A	A	A	A	A	-	B	B
10	B	A	A	A	A	A	A	A	A	-	B
11	B	A	A	A	A	A	A	A	A	A	-
	Session II										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	B	B	B	B	B	B	B	B
3	B	B	-	A	B	B	B	B	B	B	B
4	B	B	B	-	B	B	B	B	B	B	B
5	B	A	A	A	-	B	B	B	B	B	B
6	B	A	A	A	A	-	B	B	B	B	B
7	B	A	A	A	A	A	-	B	B	B	B
8	B	B	A	A	B	A	A	-	B	B	B
9	B	A	A	A	A	A	A	A	-	B	B
10	B	A	A	A	A	A	A	A	A	-	B
11	B	A	A	A	A	A	A	A	A	A	-

JUDGMENTS OF S_4 --FEMALE

Illumination Level, Circuit A	Illumination Level, Circuit B 1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	A	B	B	B	B	A	A
4	B	B	B	-	B	A	A	B	B	B	B
5	B	A	B	A	-	A	B	B	B	B	B
6	B	B	B	A	A	-	B	B	B	B	B
7	B	B	A	A	A	A	-	A	A	B	B
8	B	B	A	A	A	A	A	-	B	B	B
9	B	B	A	A	A	A	A	A	-	B	B
10	B	B	A	A	A	A	A	A	A	-	A
11	B	A	B	A	A	A	A	A	A	A	-
	Session II										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	A	A	A	A	B	B	B
4	B	B	A	-	B	A	B	B	B	B	B
5	B	B	B	A	-	B	B	B	B	B	B
6	B	B	B	A	A	-	B	B	B	B	B
7	B	B	B	A	A	A	-	B	B	B	B
8	B	B	B	B	A	A	A	-	A	B	B
9	B	B	B	B	A	A	A	A	-	B	B
10	B	B	A	A	A	A	A	A	A	-	B
11	B	B	B	A	A	A	A	A	A	A	-

JUDGMENTS OF S_5 --MALE

Illumination Level, Circuit A	Illumination Level, Circuit B										
	1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	B	A	A	A	A
3	B	B	-	B	B	B	A	A	B	B	B
4	B	B	B	-	A	A	B	B	B	B	B
5	B	B	B	B	-	B	B	B	B	B	B
6	B	B	B	B	A	-	B	B	B	B	B
7	B	A	A	A	A	A	-	A	B	B	B
8	B	A	A	A	A	A	A	-	B	B	B
9	B	B	B	A	A	A	A	A	-	B	B
10	B	A	A	A	A	A	A	A	A	-	B
11	B	B	A	A	A	A	A	A	A	A	-
	Session II										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	A	B	A	B	A	B	B
4	B	B	B	-	A	A	B	B	B	B	B
5	B	B	B	B	-	B	B	B	B	B	B
6	B	B	A	B	A	-	B	B	B	B	B
7	B	B	A	A	A	A	-	B	B	B	B
8	B	B	B	A	A	A	A	-	B	B	B
9	B	B	A	A	A	A	A	A	-	B	B
10	B	B	A	A	A	A	A	A	A	-	B
11	B	A	A	A	A	A	A	A	A	A	-

JUDGMENTS OF S_6 --MALE

Illumination Level, Circuit A	Illumination Level, Circuit B										
	1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	B	B	B	B	B	A	B	B	B	B
2	A	-	B	B	B	B	B	A	B	A	B
3	A	A	-	B	B	B	B	B	B	B	B
4	A	A	A	-	B	B	A	B	B	B	B
5	A	A	A	A	-	B	B	B	B	B	B
6	A	A	A	A	A	-	B	B	B	B	B
7	A	A	A	A	A	A	-	B	B	B	B
8	A	A	B	A	A	A	A	-	B	B	B
9	A	A	A	A	A	A	A	A	-	B	B
10	A	A	A	A	A	A	A	A	A	-	B
11	A	A	A	A	A	A	A	A	A	A	-
	Session II										
1	-	B	A	B	A	B	B	B	B	B	B
2	B	-	A	B	B	B	B	B	B	B	B
3	A	A	-	B	B	B	B	B	B	B	B
4	A	A	B	-	B	B	B	B	B	B	B
5	A	A	A	A	-	A	B	B	B	B	B
6	A	A	A	A	A	-	B	B	B	B	B
7	A	A	A	A	A	A	-	B	B	B	B
8	A	A	A	A	A	A	A	-	B	B	B
9	A	A	A	A	A	A	A	A	-	B	B
10	A	A	A	A	A	A	A	A	A	-	B
11	A	A	A	A	A	A	A	A	A	A	-

JUDGMENTS OF S_7 --MALE

Illumination Level, Circuit A	Illumination Level, Circuit B 1	2	3	4	5	6	7	8	9	10	11
					Session I						
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	B	A	A	B	A	A	A
4	B	B	A	-	A	B	A	A	A	B	A
5	B	B	A	A	-	B	B	B	B	B	B
6	B	B	A	A	A	-	A	B	B	B	B
7	B	B	A	B	A	A	-	B	B	B	B
8	B	B	A	A	A	A	A	-	B	B	B
9	B	B	A	A	A	A	A	B	-	B	B
10	B	B	A	A	A	A	A	A	A	-	B
11	B	B	A	A	A	B	A	A	A	A	-
					Session II						
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	A	A	A	A	B	A	A
4	B	B	B	-	B	B	B	B	B	B	B
5	B	B	A	A	-	B	B	B	B	B	B
6	B	B	B	A	A	-	B	B	B	B	B
7	B	B	A	A	A	A	-	B	B	B	B
8	B	A	A	A	A	A	A	-	B	B	B
9	B	A	A	A	A	A	A	A	-	B	B
10	B	B	A	A	A	A	A	A	A	-	B
11	B	B	A	A	A	A	A	A	A	A	-

JUDGMENTS OF S_8 --MALE

Illumination Level, Circuit A	Illumination Level, Circuit B										
	1	2	3	4	5	6	7	8	9	10	11
	Session I										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	A	A	A	A	A	A	A
4	B	B	B	-	A	A	A	A	A	A	A
5	B	B	B	B	-	A	B	A	A	B	A
6	B	B	B	B	A	-	B	A	B	B	B
7	B	B	B	B	B	A	-	A	B	A	B
8	B	B	B	B	B	A	B	-	A	B	B
9	B	B	B	B	B	B	A	A	-	A	B
10	B	B	B	A	A	A	A	A	A	-	B
11	B	B	B	B	B	A	A	A	A	A	-
	Session II										
1	-	A	A	A	A	A	A	A	A	A	A
2	B	-	A	A	A	A	A	A	A	A	A
3	B	B	-	A	A	A	A	A	A	A	A
4	A	B	B	-	A	A	A	A	A	A	A
5	B	B	B	B	-	A	A	A	A	B	A
6	B	B	B	B	A	-	B	A	A	B	B
7	B	B	B	A	B	B	-	A	B	B	B
8	B	B	B	B	B	B	A	-	A	B	B
9	B	B	B	B	B	A	A	A	-	B	B
10	B	B	B	B	B	A	A	A	A	-	B
11	B	B	B	A	A	A	A	A	A	A	-