of vision at the computed point of infinitely large stimulus-differences.

But the data for estimated number (Figure 121) do not rectify on hyperbolic coordinates and cannot be extrapolated to any value at infinity. (We repeated the experiment with a second group of subjects whose data did not rectify either.) We have already mentioned that sorting for this aspect was less accurate than for subitized number and texture-density. Sorting was also more variable and, as can be seen in Figure 121, considerably slower. But the data show that sorting time decreases and accuracy increases as a function of the size of the stimulus difference. For the largest stimulus differences, estimated number was discriminated just about as quickly and accurately as the other discriminable aspects.

At this point a comment is in order concerning the units of measurement of the stimulus differences which were used in the hyperbolic plots. One reasonable hypothesis would state that the time required for discrimination is related to the size of the stimulus difference by a hyperbolic function only when the stimulus differences are expressed in units which are subjectively equal. In the case of saturation (where hue was the aspect being sorted) the positions from the Munsell color series which were used in measuring the stimulus differences are known to constitute a scale of approximately equal subjective units. Although for area, subitized number, and estimated number the stimulus differences were expressed in units from a physical scale, there are experimental studies which indicate equal distances along these scales are approximately equal subjectively. There is also some reason for believing the same correspondence between the physical and subjective scales holds true for texture-density. It is possible, however, that under the particular conditions used in the experiment in which sorting was on the basis of estimated number, the physical and subjective scales were not linearly related. In this case, it might be expected that the data for estimated number would not rectify on hyperbolic coordinates. However, there may well be other reasons why these time data did not rectify on hyperbolic coordinates.

Most of the stimulus differences were small in the experiment using the number of objects in the estimating range. As it turns out, the smallest difference was less than 1 jnd (just noticeable difference or differential limen). We calculated the number of jnd's of our stimulus differences from Taves' study on visual numerousness.* Taves worked out the jnd for 5 standards, ranging from 15-180 dots. We averaged the data for his subjects and plotted the jnd against the number of dots in the standard stimulus. The jnd's for the dot numbers used in the present experiment were read from points interpolated on this curve. We found that our smallest stimulus difference (2, in the pack containing 17 and 19 dots) was only 0.51 jnd. Our largest stimulus difference in this experiment (10, in the pack containing 13 and 23 dots) was only 2.58 jnd's. The much higher percentage of sorting errors for estimated number, at all but the two largest stimulus differences, supports the view that the stimulus differences were subjectively smaller for estimated number than for the other aspects. The data from this experiment suggest, therefore, that a reciprocal relation between discrimination time and stimulus difference holds only for stimulus differences well above the jnd. We think this may be true for other discriminable aspects. As will be seen in the next experiment to be reported, there is evidence strongly supporting this statement for at least one other discriminable aspect.

* Taves, E. H., Two mechanisms for the perception of visual numerousness, *Arch. Psychol.*, 37, 1941 (no. 265), 1-47.

In summary, the results of this experiment indicate that differences in subitized number and texture-density are rapidly and accurately discriminated, and that these aspects would therefore make good coding variables. They further indicate that differences in estimated number are relatively slowly and inaccurately discriminated, and that this aspect would therefore make a poor coding variable. Now undoubtedly, estimated number would be rapidly and accurately discriminated if the differences in number were more than 1 or 2 jnd's. However, in a practical situation, it might not prove convenient to make symbols large enough to accomodate the large numbers of dots that this would require.

3. *The Fine Discrimination of Area*

We wanted to test the foregoing hypothesis that the reciprocal relation between discrimination time and size of stimulus difference holds only for values above the jnd. So the experiment now to be described involves a fine analysis of the discrimination of differences in visual area, both below and above the differential threshold. There were two other objects of the experiment which are as important for Section X (on the psychology of judgment) of this Summary Report as for this section. In the first place, we were interested in determining, by a fine analysis, whether, in a *simultaneous comparison of areas*, discrimination takes place in quantal fashion (i.e., in discrete steps) or continuously. Secondly, the experiment contained a similar fine analysis of the estimates of the subjects' confidence. Thus, we collected data on the accuracy, speed, and confidence of discriminating differences between two simultaneously presented visual areas.

a) *Procedure.* The technique of this experiment emphasized the precise control of visual area stimuli, a large number of values of the independent variable (stimulus difference), a large number of observations for each value of stimulus difference and for each subject, and favorable viewing conditions for the subject.

The apparatus is described in detail in the appendix (VIII:H:2:d). It consisted of a tachistoscope in which a standard and a comparison area were presented simultaneously. The stimuli were small black squares, displaced horizontally from each other upon a white field. (See Figure 133, VIII:H:2:d.) The area of the comparison stimulus could be varied continuously and accurately, so as to be either larger or smaller than the standard stimulus. The method of constant stimulus differences was used throughout the experiment. Stimuli of various sizes were compared in random order with a standard stimulus area. Subjects were instructed to respond quickly once they were sure of the accuracy of their discrimination. The experimental routine was as follows. After appropriately setting the size of the stimulus area, the experimenter said "ready" and pressed a telegraph key, presenting the stimulus field and starting a chronoscope. The subject first responded by pressing the telegraph key on the same side as the *larger* stimulus area (thus stopping the chronoscope), and then set a confidence indicator to her estimated level of confidence. (The confidence indicator is described in VII:F:4.)

There were two parts in this experiment. The principal difference between the two parts concerned the length of time the stimuli were presented. In Part 1, the stimuli were exposed until the subject pressed one of her keys (which automatically turned off the stimuli). In Part 2, the stimuli were always presented for 0.4 sec. The latter procedure was adopted in an attempt to reduce variability in the data which may have resulted from one feature of Part 1, from our lack of control of the number of times that the subjects could look back and forth between the two stimulus areas before responding. In both parts, the standard stimulus area was 9.00 sq. mm. In Part 1, the area of the comparison stimuli ranged through 39 values from 8.00 sq. mm. to 15.00 sq. mm. Many values of stimulus difference close to equality were included. It was our

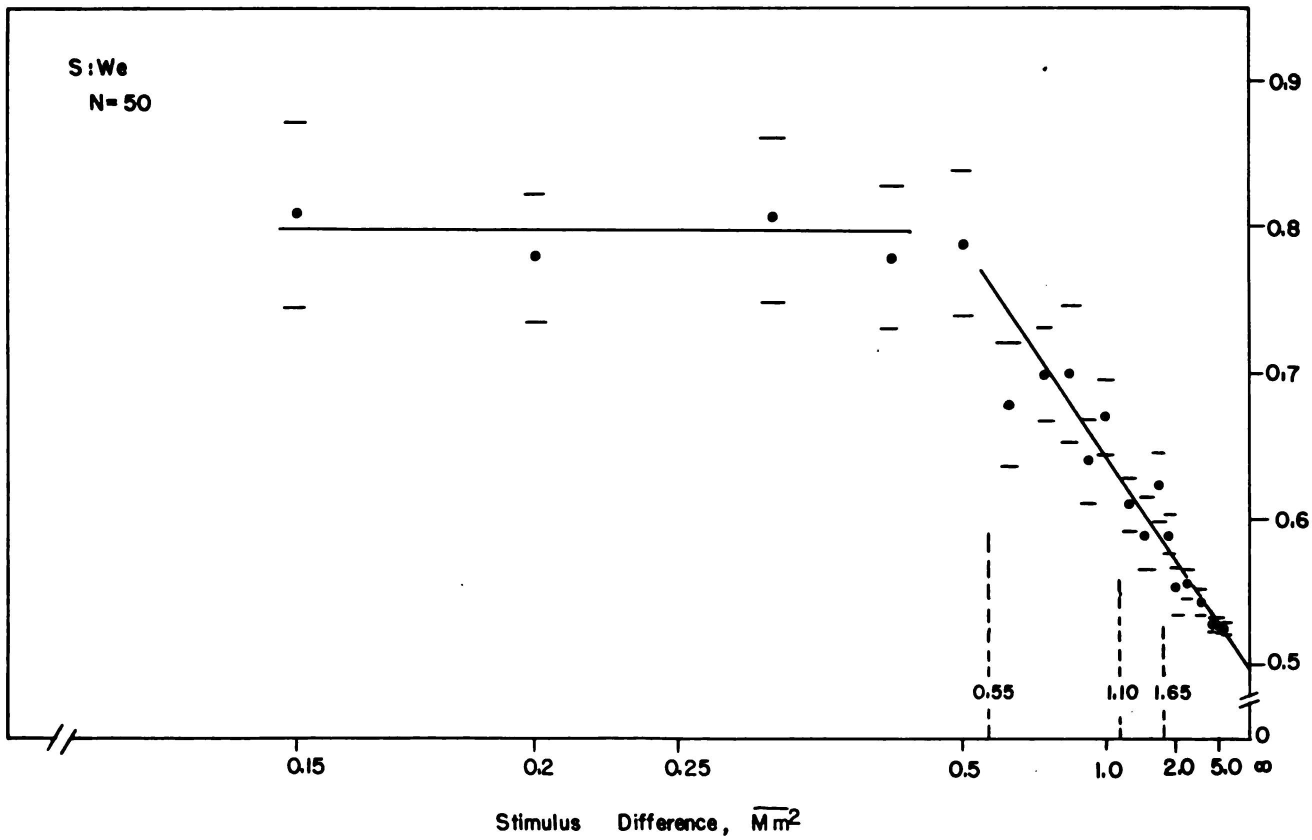

Figure 123
Median Time in sec. as a Function of Stimulus Difference in sq. mm. Simultaneous comparison of areas; 1 subject; coordinates hyperbolic.

hope that the end of the range would extend to differences well beyond the point of 100% accuracy and maximum confidence.

For each subject in Part 1, the number of judgments was 200 for all stimulus differences close to equality, 50 for the largest values of stimulus difference, and 100 for stimulus differences of intermediate value. There were five subjects, all having normal vision without glasses. Experimental sessions lasted one hour, during which approximately 200 judgments were obtained. Each subject in Part 1 made a total of approximately 6,850 judgments.

In Part 2 of the experiment, the comparison stimuli ranged through 29 values from 7.60 sq. mm. to 10.4 sq. mm. Each of two subjects made 300 judgments for each stimulus difference. As previously stated, the stimuli were presented for 0.4 sec. Data on time, confidence, and accuracy were collected, as in Part 1.

b) *Results.* Figure 123 shows one of the principal results of this experiment. The figure shows, for one subject, the median discrimination time plotted as a function of the stimulus difference (in sq. mm.), on hyperbolic coordinates. The data are well fitted by two straight lines of different slope. The point at which these straight lines would intersect lies at the stimulus difference that is approximately the jnd. For values of stimulus difference below the jnd, the figure shows that discrimination time is approximately constant. (For two subjects the upper branch of the functions on these coordinates had some negative slope.) For values of stimulus difference above the jnd the familiar reciprocal relation is found (as evidenced by the straight line on hyperbolic coordinates).

The data from Part 1, therefore, lend support to our previous hypothesis that discrimination time will be a reciprocal function of stimulus difference when that difference is safely above the jnd. The data from Part 1 are so clear that the further data on discrimination time from Part 2 will not be presented here.

An analysis of the confidence settings made by each subject indicated that there was some tendency for them to fall into a number of separable frequency distributions, having very different modes. After taking careful note of the apparent consistencies which ran through the data of all the subjects, we were led tentatively to suggest that there were 3 different distributions of confidence, ranging approximately from 0 to 50, 51 to 90, and 91 to 100% on the confidence scale. In Figure 124, right, there is some indication of these separable distributions, especially for a stimulus difference of 1.6 sq. mm. The data from Part 2 indicate much more clearly that the confidence settings fall into separable distributions, each with very different modes. In Figure 124, left, we can see 4 distinct modes in the confidence settings, centered about 0, 50, 75, and 100 respectively. This is the data for an individual subject. There is some evidence in the data that these distinct modes of confidence settings are related to quantal phenomena. In the absence of further supporting evidence, however, we will not further develop this hypothesis in the present report.

Another interesting finding concerning confidence settings can be seen from Figure 124. As the values of the independent variable (stimulus difference) decrease, approaching and then passing the value of the standard stimulus, the populations in the different confidence modes also shift. It is clear from the figure that, as would be expected, the general level of confidence decreases, on the average, as the stimulus difference becomes smaller and then zero. Confidence modes are still observable when the stimulus difference is "negative", i.e., the smaller area is judged as "greater". Having found an inverse relation between discrimination time and size of stimulus difference, and a direct relation between confidence and size of stimulus difference, it follows that there is an inverse relation between discrimination time and confidence.

Before presenting the psychometric functions in this experiment, we shall describe briefly the quantal theory of discrimination. This theory assumes that to discriminate an increment to a stimulus, one additional "neural unit" (as yet, not specified anatomically) must be excited. Therefore, as the size of a visual stimulus area is very gradually and uniformly increased, for example, one should at first discriminate no change in the area and then, suddenly the area should appear larger (by one minute step, or "quantum"), as one additional neural unit is excited. Quantal theory further assumes that the organism's over-all sensitivity to stimulation fluctuates gradually and randomly over several quanta. Whenever a stimulus is presented, there will be a certain number of neural units excited. But there will also nearly always be some residual stimulation which is not great enough to excite the next neural unit. The size of this residuum will determine how large a stimulus increment must then be presented for it to be discrimination as an increment. If you repeatedly present the same standard stimulus, the amount of residual stimulation will also fluctuate randomly (as sensitivity does), with the result that the probability of one residuum being present will be equal to the probability of any other residuum being present. The smallest stimulus difference which will always excite an additional neural unit, i.e., will always be discriminated, we will call a "quantal difference". The probability, then, of a particular stimulus difference being discriminated will be equal to the ratio of that difference to the quantal difference. Therefore, if quantal discrimination holds, the psychometric function should be *linear*, having its origin at the point of zero stimulus difference and reaching 100% at one quantal difference.

Our development of quantal theory above has implicitly assumed: (a) the time intervals used are brief enough so that no appreciable change in sensitivity occurs during the presentation of the two stimuli being compared, (b) all other experimental conditions are "ideal", i.e., do not interfere with the subject's discrimination in any way, (c) a one-quantum change can always be discriminated, and (d) there is but one opportunity for discrimination each time the paired stimuli being compared are presented. Under some experimental conditions, however, the subject may not consistently maintain a one-quantum criterion, but may use a two-quantum criterion part of the time, i.e., she may not always recognize a one quantum change as a stimulus change. Moreover, under condi-

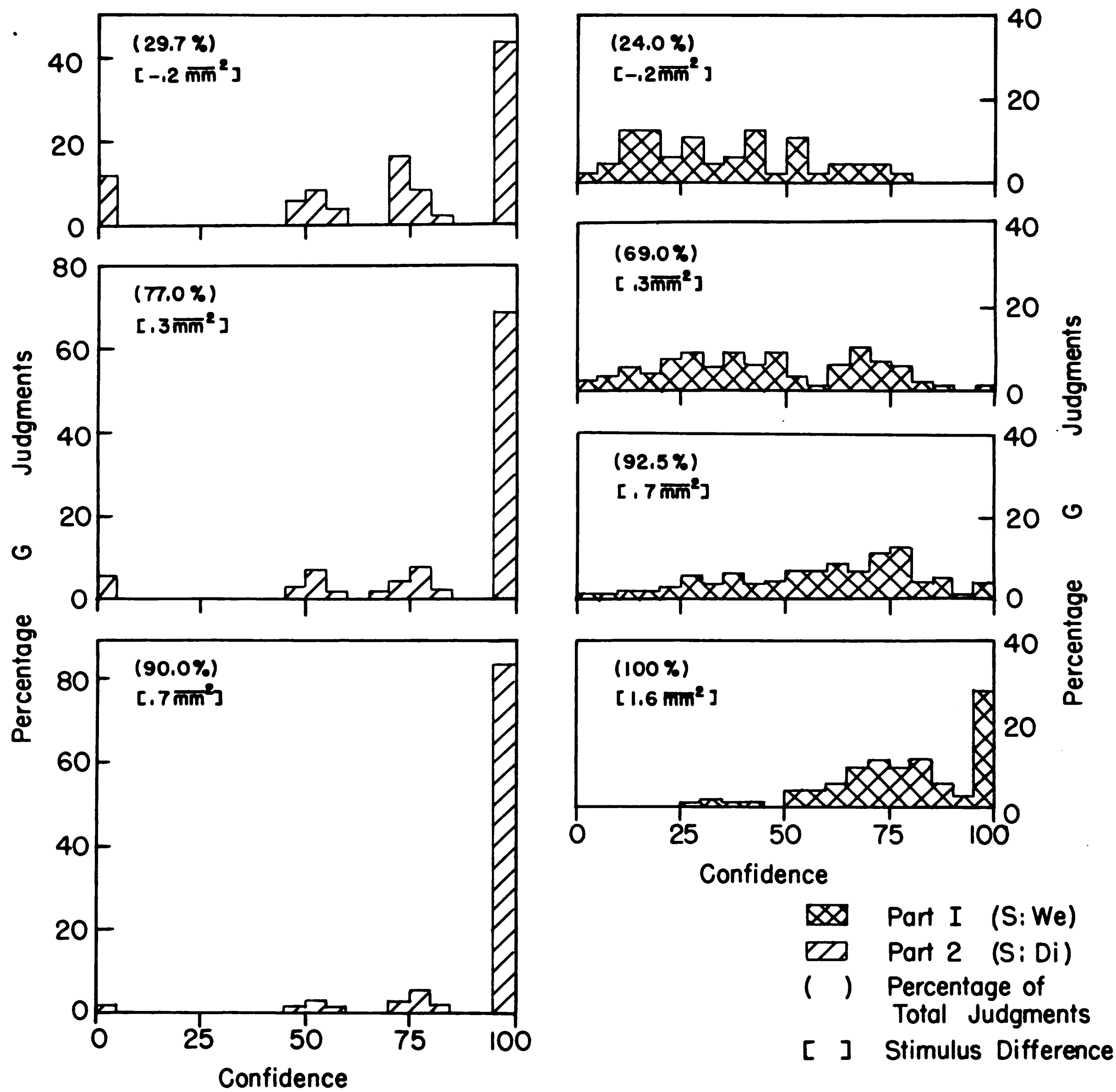

Figure 124

Frequency Distributions of Confidence when Stimuli Exposed 0.4 sec. (left) and as Long as Subject Needed to Respond (right). Percentage of greater judgments plotted against confidence; percentage of total judgments that were greater given in parentheses; difference between comparison stimuli given in brackets; 2 subjects.

tions of ***simultaneous comparison*** of standard and comparison stimuli which are spatial, (e.g. area) there may be ***two*** statistically independent opportunities for discrimination. (This would be true, for example, if, in the discriminatory mechanism, the two spacial stimuli are represented in two different places and if some representation of the *other* stimulus is conveyed to each place.) Making the latter two assumptions, one can easily compute a theoretical psychometric function. For example, if we assume 85% first-quantum and 15% second-quantum discrimination, as well as two independent chances for discrimination, we obtain the theoretical psychometric function shown in Figure 125. (It should be mentioned here that at the present time there is no rational basis for determining what percent of the time one-quantum and two-quanta criteria are employed by the subject. This determination is empirical, and

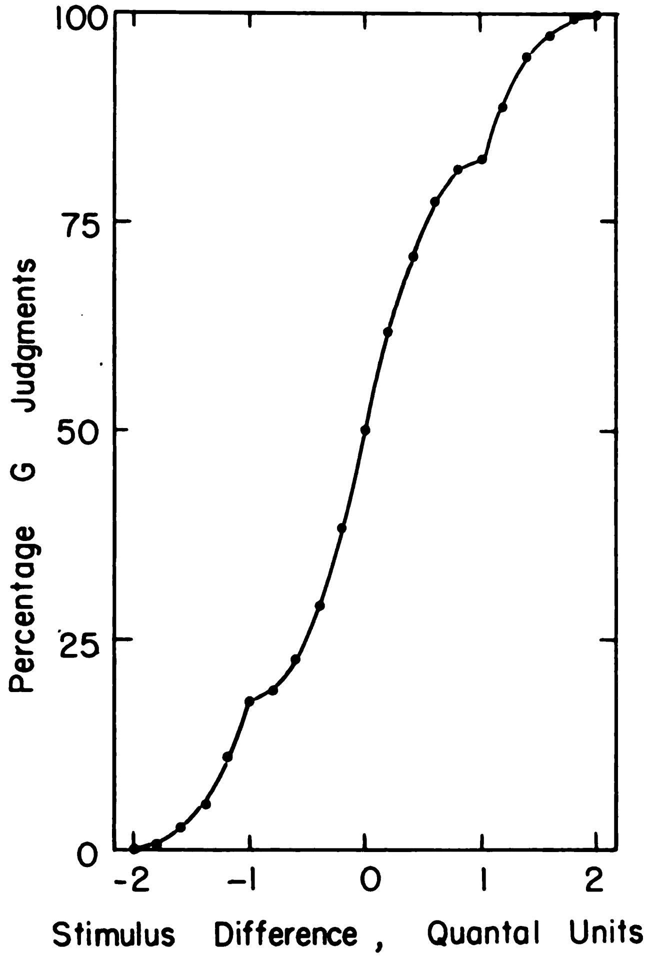

Figure 125

Theoretical Psychometric Function Based on Quantal Theory of Discrimination. Percentage of greater judgments plotted against stimulus difference in quantal units.

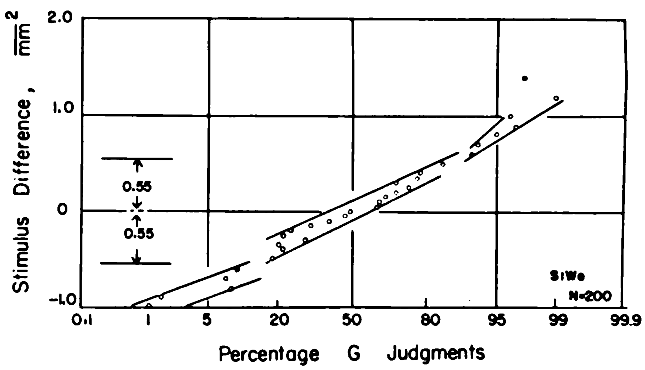

Figure 126

Obtained Psychometric Function. Stimulus difference in sq. mm. plotted against percentage of greater-than judgments; 1 subject; N of 200; coordinates arithmetic probability.

the general form of the psychometric function does not depend upon it.) According to the classical theory of sensory discrimination, the action of a large number of random influences should produce a psychometric function which is approximately sigmoid (the integral of the normal probability curve). Moreover, even though discrimination is quantal, under any departure from "ideal" experimental conditions the psychometric function might be expected to approach the sigmoid form.

Returning now to the experimental results, there are a number of small, but persistent evidences in the psychometric functions that quantal discrimination in some form is at work. Figure 126 shows the psychometric function for a single subject in Part 1, as replotted on probability paper. The function is not one straight line or band as classical theory would predict. Rather, the function seems to be broken into three separable segments, i.e., it has two distinct discontinuities in the first derivative (excluding the two discontinuities of the two ends of the function). All of the other psychometric functions obtained showed some evidence of segmentation. (Note that subjects responded to a zero stimulus difference as "greater" approximately 50% of the time because they were required to indicate upon every stimulus presentation which one of the two stimuli was greater. Consequently, they made "pure guesses" at zero stimulus difference, thereby judging the comparison stimulus as greater approximately half the time.) It is of further interest that the two discontinuities in the psychometric functions are approximately symmetrical around zero stimulus difference for all the subjects in Part 1. The theoretical psychometric function in Figure 125 also contains two discontinuities, similarly placed. The theory states that the value of stimulus difference which lies at the points of discontinuity is the quantal difference. This has been designated in Figure 126. Although the variability in individual data is too great to permit a detailed comparison between the observed psychometric functions and those based upon quantal assumptions, the observed discontinuities lend some support to the validity of these assumptions. There is, moreover, much stronger evidence for quantal phenomena in Part 2 of the experiment. Due probably to the controlled time of stimulus presentation and to the greater number of judgments obtained, the data in Part 2 are less variable than in Part 1. Therefore, a more detailed inspection of the shape of the psychometric function is possible. In Figure 127 a curve was drawn empirically through the plotted points. The similarity between the form of this curve, around which the data fall closely, and that of the theoretical curve in Figure 125 is quite striking.

There were three principal results in this experiment. First, a reciprocal relation was found between discrimination time and size of stimulus difference

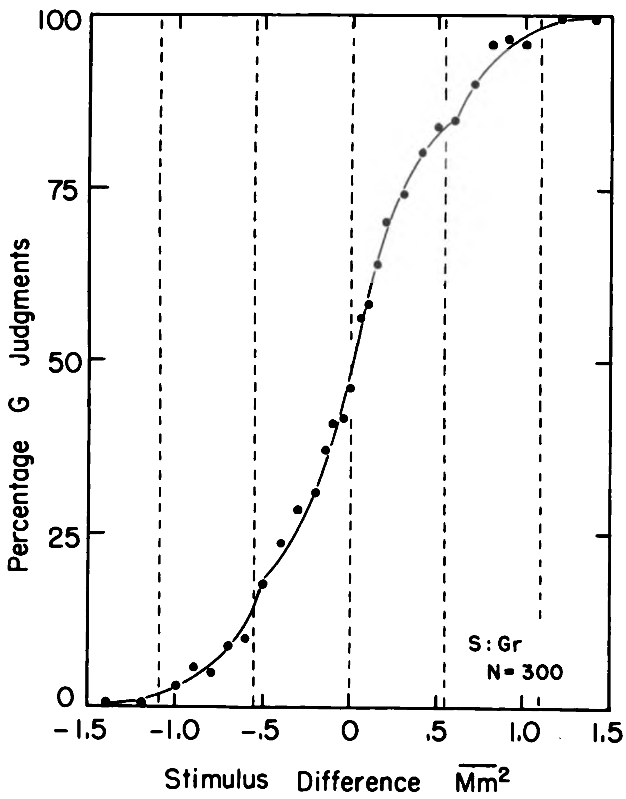

Figure 127
Obtained Psychometric Function. Percentage of greater-than judgments plotted against stimulus difference in sq. mm. Quanta indicated by dotted lines; 1 subject; N of 300.

for values of stimulus difference greater than the jnd, while discrimination time was nearly constant for values less than the jnd. Secondly, confidence settings tended to fall into a number of separable frequency distributions having very different modes. Also, confidence level was found to increase directly as a function of size of stimulus difference. Thirdly, some evidence was found which supported the quantal theory of sensory discrimination.

G. Conclusions

1. Under the conditions of our experiment, as many as 5 values of a single discriminable aspect may be used as coding variables, if a total percentage error of 5% can be tolerated. Errors are made most frequently on the middle stimulus values. These errors can probably be reduced by shifting the middle stimulus values out toward the end values. (VIII:B)

2. The process of searching a visual field occurs in successive, discrete stages. Under the conditions of our experiment, the number of objects a subject can search in one look is limited to 3 or 4. (VIII:C)

3. The best shape of a near-threshold symbol for indicating direction resembles the letter "T". (VIII:D)

4. The discriminable aspects hue and shape are discriminated more rapidly than area and brilliance whether single or compounded, and whether the remaining aspects are varied or held constant. Hue is the most rapidly discriminated of the 4 aspects under all conditions. With one exception, hue is also the most accurately discriminated aspect. (VIII:E:1,2)

5. No matter what discriminable aspects are used, and whether or not they are compounded, the speed and accuracy of discrimination are greater when the remaining aspects are held constant than when they are varied. (VIII:E:2)

6. When the remaining aspects are held constant, the speed and accuracy of sorting compounded aspects are slightly greater than for sorting either aspect singly. We cannot make a definite statement about the comparison of single and compounded aspects when the remaining aspects are varied. (VIII:E:2)

7. Speed of discrimination is related to the size of the difference between two values of a discriminable aspect by a reciprocal function which approaches a constant discrimination time as the differences become very large. The time necessary to discriminate "infinitely" large differences seems to be independent of the discriminable aspect. (This statement is based on the results from 2 different techniques and on the use of 4 discriminable aspects.) (VIII:F:1,2)

8. The reciprocal relation between speed of discrimination and size of stimulus difference holds only for differences above the jnd. Below the jnd, the speed of discrimination is nearly constant. (VIII:F:3)

9. Subjects' confidence in the correctness of their discrimination appears to vary in discrete steps. (VIII:F:3)

10. Evidence was found, which suggests that the visual discrimination of area is quantal in nature. (VIII:F:3)

H. Apparatus Appendix to Section VIII

1. *Sorting Box*

The description of this sorting box applied to all the experiments (except X:C:1) in which the method of card sorting was used. The cards which were sorted into the box differed for each experiment, and are therefore described with the experimental procedure in the appropriate sections of the text.

Figure 128 shows a subject sorting a pack of cards, into either side of the two-compartment box. The overall dimensions of this box, which is made of wood, are 6 in. by 24 in. On either side of the box the cards fall on a smooth metal slide which is inclined 50° downward from the horizontal. The 2 slides meet at the top of the box in the center. In this way the distance between the 2 compartments is minimized so that the subject can sort comfortably from one position without having to rotate from side to side. The cards fall into one of 2 covered compartments, each 3 1/2 in. by 5 in. A cardboard tray which received the cards fits into the bottom of each compartment. This tray can be pulled out to remove the cards.

photo, Max Kotfila

Figure 128
Two Compartment Box for Sorting Cards Containing Stimuli.

The wooden back of the box is rounded upward to the center height of 11 in. so that the cards can be flipped into the box without missing their mark. Signs are placed on either side of this back board to remind the subject where the cards are to go. (The subject in the figure is sorting small circles into the left- and large cirlces into the right-hand compartment.)

The box is placed on a low table in a comfortable sorting position. It is lighted by a 150 w. flood lamp mounted on a support 6 1/2 ft. high, where it shines over the left shoulder of the subject. In this position, the lamp seems to give ample illumination and a minimum of shadowing and glare.

2. *The Modified Dodge Tachistoscope*

This apparatus has been used in our laboratory for several quite different experiments. The basic design of the apparatus was the same for all of these experiments, but there were important modifications in each case. These modifications are listed below, following the general description.

The tachistoscope consisted of a steel box, roughly 16 x 14 x 16 in. The inside of the box was painted black. There was a circular hole in the center of the front of the box, 4 1/2 in. in diameter. Another circular hole, 2 1/4 in. in diameter, was made in the center of the back of the box. The stimulus cards were placed

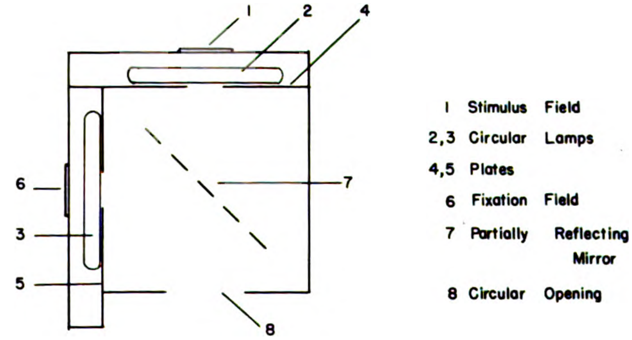

Figure 129
Diagram of Modified Dodge Tachistoscope.

here and were held in position by a metal plate in back of the hole. A similar hole was made in the left side of the box for the fixation field. The subject looked through the front hole at either the stimulus field or at a *reflection* of the fixation field. The fixation field was reflected by a partially reflecting mirror (10 x 13 in., 15% reflection) placed vertically and diagonally in the box. This mirror was adjusted so that when the fixation field was illuminated, it appeared in exactly the same position as the stimulus field. Figure 129 is a diagram of the tachistoscope.

The fixation field and the stimulus field were each lighted by a 32 w. circular, fluorescent lamp, mounted behind a removable steel plate inside the box. The lamps were operated on DC, furnished by a special power supply. While one lamp was lighted the other was heating, so that it could flash on without delay.

The apparatus was wired to give the following sequence of events: the experimenter pressed a key; this energized the coil of a holding relay which in turn closed two sets of contacts, one leading to the chronoscope and other to the coil of the tachistoscope relay; when the tachistoscope relay coil was energized, the circuits through the stimulus lamp and through the heater coil of the fixation lamp were completed. In other words, when the experimenter pressed the key, the fixation lamp went off, current passed through the heater coil of the fixation lamp, the chronoscope started, and the stimulus lamp went on. When the subject responded, she pressed another key (usually one of the two keys). This completed the circuit to one of two signal lamps (indicating the accuracy of response), opened the holding relay, and opened the tachistoscope relay. So the signal lamp went on, the chronoscope stopped, the stimulus lamp went off, current passed through the heater coil of the stimulus lamp, and the fixation lamp went on. A block diagram of the apparatus can be seen in Figure 130. Figure 131 shows one of the modifications of the tachistoscope from the experimenter's viewpoint. This figure also shows from left to right: the relays, power supply, experimenter's key, stimulus cards, and chronoscope.

Modifications

a) *Range of Visual Search* (VIII:C)

This experiment required two major changes in the apparatus. First of all, the subjects did not respond by touching a key. Instead, they touched a piece of glass (a window) in the front hole of the tachistoscope. This window was supported by three pairs of spring contacts, wired in series. Touching it at any point had the same effect as pressing the subject's key in the standard apparatus, i.e., stopped the chronoscope and turned on the fixation field. A second

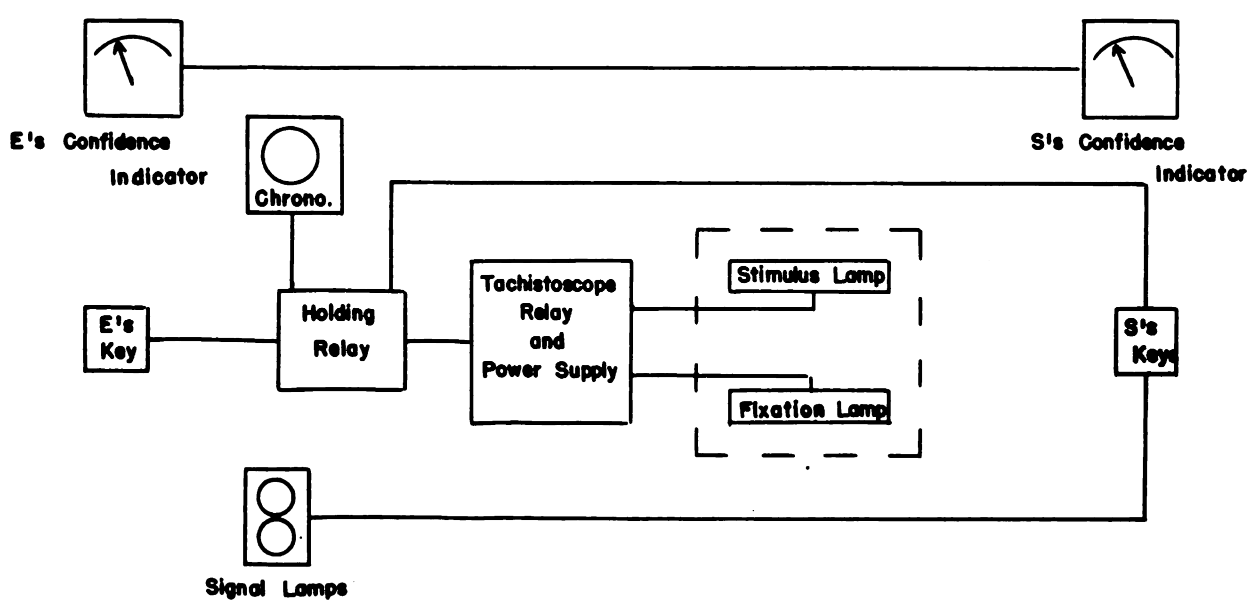

Figure 130
Block Diagram of Apparatus Including Modified Dodge Tachistoscope used in Experiment VIII:F:3.

change was the addition of a viewing tube which extended from the top of the tachistoscope. This viewing tube is shown in Figure 131. Through this tube, the experimenter could see the subject's finger as it touched the window, and the stimulus field apparently *superimposed* upon the window. Thus the accuracy of response could be checked. A 6 x 6 in. partially reflecting mirror was placed at the base of the tube at a 45° angle with the front of the tachistoscope. The tube was fixed so that the experimenter looked directly at the front window and at a reflection of the stimulus field. Right and left inverting prisms in the tube corrected the reflected letters for the experimenter. The front panel of the tachistoscope was illuminated by a 7 w. bulb, housed in a metal case, and dimmed by an attached strip of lucite.

b) *The Discrimination of Hue and Area as a Function of Stimulus Difference* (VIII:E:1:b)

In this experiment, two cards were presented simultaneously. Therefore, two holes for stimulus fields and two holes for fixation fields were required. The holes were each 2 1/4 in. in diameter and about 1/2 in. apart. Otherwise the apparatus was unchanged.

c) *The Discrimination of a Constant Difference in Number* (VII:B:9:b)

There were several changes in the apparatus for this experiment. For both sections of the experiment, there were two stimulus fields and two fixation fields. During the second part of the experiment, the subject viewed the field through a rectangular rather than a circular opening in the front of the tachistoscope.

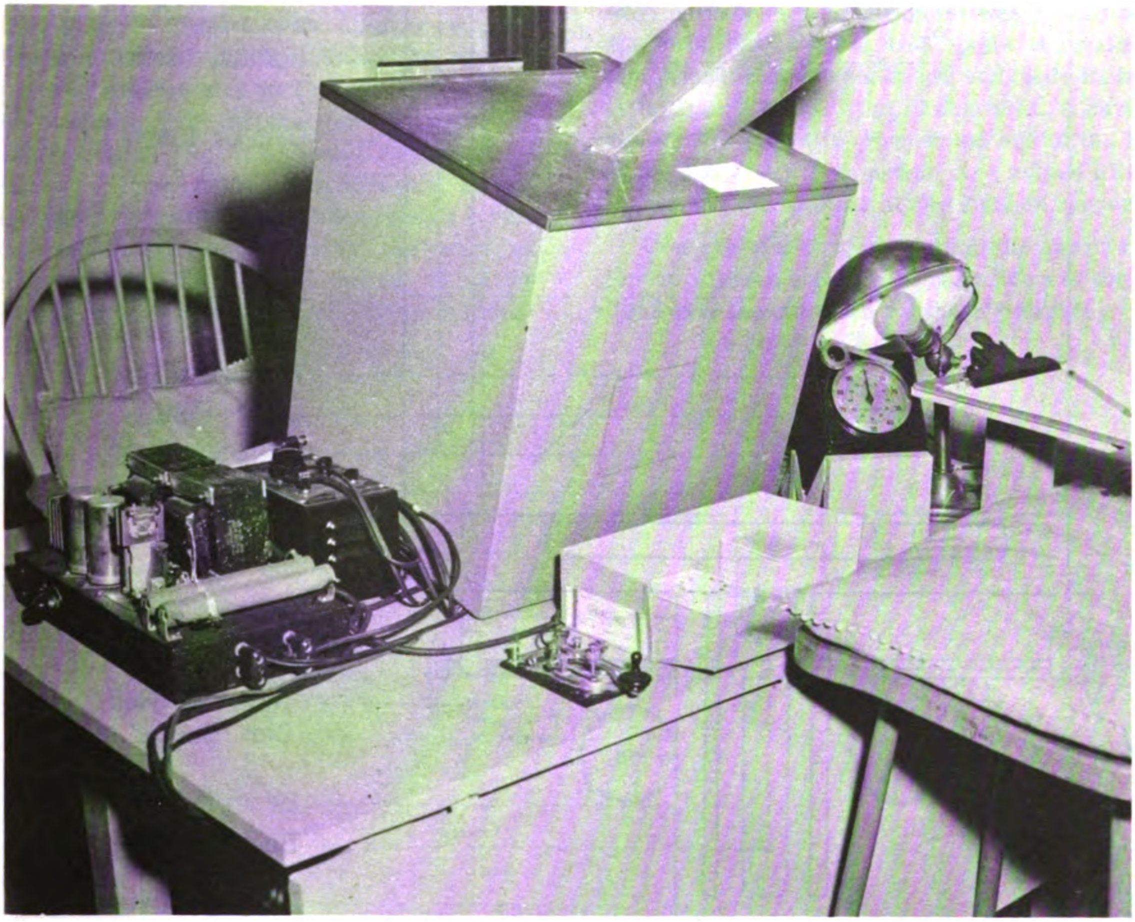

Figure 131 photo, Max Kotfila

Modification of Dodge Tachistoscope Used in Experiment on Range of Visual Search. From left to right in front of tachistoscope: relays, power supply, experimenter's key, stimulus cards, and chronoscope.

Also, the fixation field was provided in a different way. A rectangular metal box was placed on the center of the top of the tachistoscope. This box was divided vertically into two sections by an opaque partition. Frosted glass covered the opening of each section into the tachistoscope. The glass was covered with black paper, and two circles, 2 1/4 in. in diameter, were cut out of the paper. The circles could appear in a partially reflecting mirror placed at an angle below the rectangular opening in the front of the tachistoscope. When either of the two circles was illuminated by a small bulb, a blank circle appeared to the subject in the position of one of the two stimulus circles.

A rotating disk timer controlled the presentation of the stimuli in the following way: the experimenter pressed her key; this started the timer, which turned on the left stimulus field and left on the right fixation field for 1/4 sec. (both fixation fields were on prior to presentation of the stimuli); then both fixation fields were on for 1/2 sec., and finally the right stimulus field and the left fixation field were on for 1/4 sec. So the subject saw first two blank circles, then one stimulus for 1/4 sec., then the blank circles for

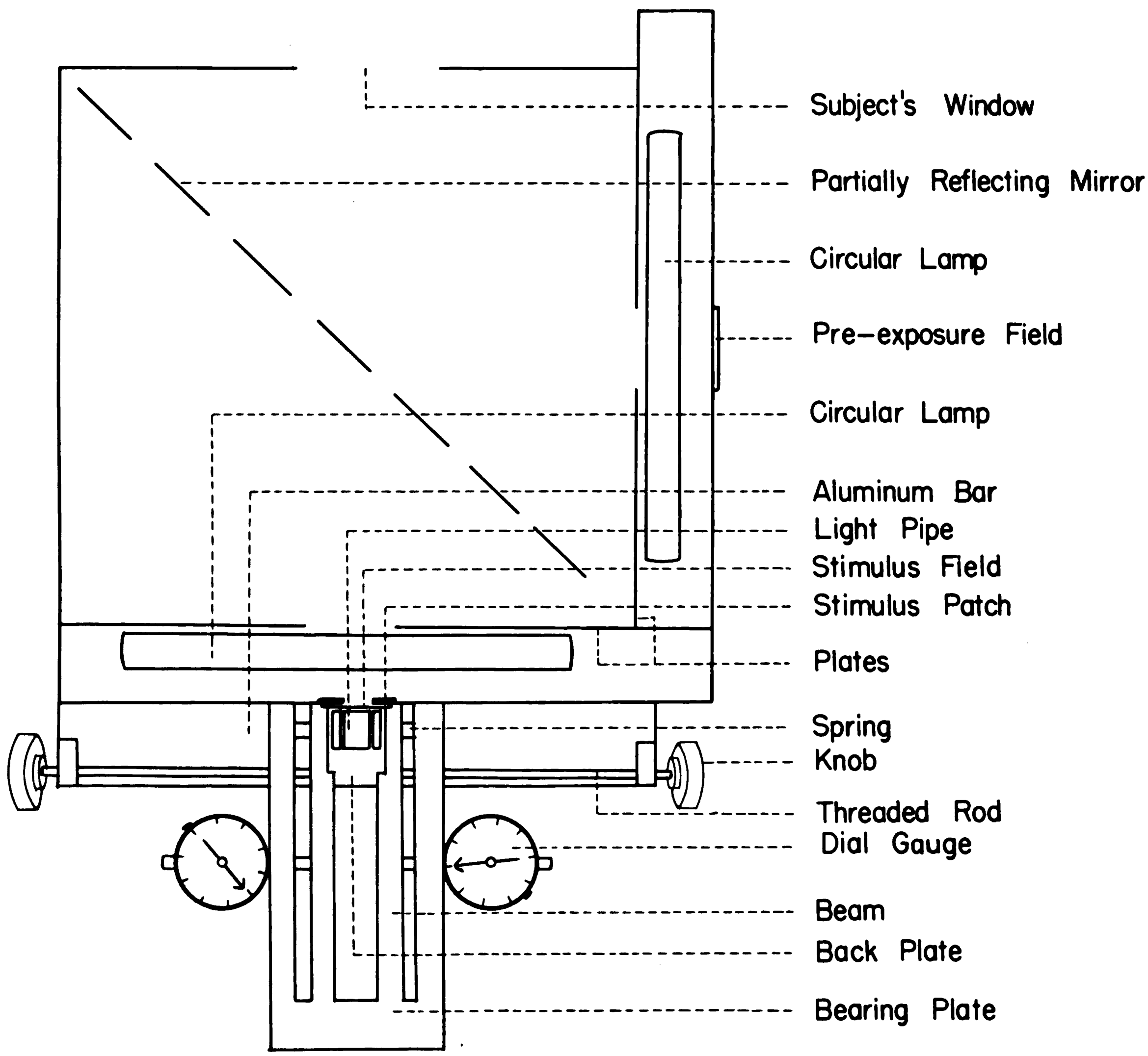

Figure 132
Diagram of Modified Dodge Tachistoscope and Apparatus for Producing Stimulus Field for a Simultaneous Comparison of Areas, seen from above.

1/2 sec., and finally the other stimulus for 1/4 sec. The subject's key caused both fixation fields to go on.

d) *The Fine Discrimination of Area* (VIII:E:3)

The stimuli for this experiment were not symbols on cards, but two black squares which varied in area. Therefore, the apparatus required several important modifications. Figure 132 is a diagram of the tachistoscope and the apparatus for producing the stimulus field. The stimulus field was placed behind a rectangular hole, 1 1/2 x 3/4 in., cut in the back of the tachistoscope. The field consisted of a piece of opaque white plastic 4 1/2 x 2 in. into which lozenge-shaped, hexagonal aperture, 2 cm. long, was cut with great care. Two black plastic patches were placed behind either end of the aperture. There was also another piece of white plastic behind the aperture. Two sides of each patch were exposed and these two sides formed a 90° angle. The sides of the angle also formed a 90° angle so that each black patch appeared as a square set upright on a corner. The outline of the lozenge-shaped aperture was slightly visible. Figure 133 is a drawing of the stimuli. The patches could be moved horizontally in line with the center axis of the aperture. This increased or decreased the area of each square. Each patch was attached to a metal beam 8 in. long. A long, threaded rod, ending in a knob, moved the beam horizontally, giving a very fine adjustment. A gauge bore against the center of each beam registering the distance through which the beam moved to the nearest 0.005 mm. Thus the horizontal diagonal of each square was controlled within 0.001 mm., and the area of the square was accurate to the nearest 0.05 sq. mm.

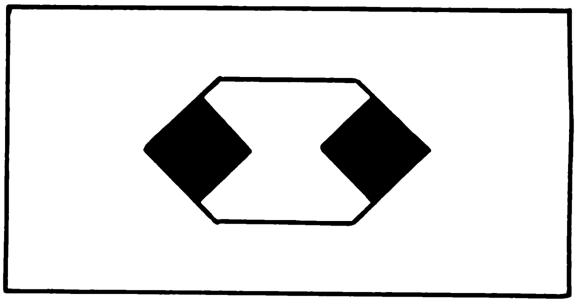

Figure 133
Drawing of Stimulus Field for Simultaneous Comparison of Areas. Black plastic patches located behind lozenge-shaped aperture.

The front of the lozenge-shaped stimulus field was lighted by the usual circular lamp. The back of the field (inside the lozenge) was lighted in the following way. A white plastic backplate was placed behind the aperture, tilted back at a 55° angle. A plexiglas light-pipe illuminated the backplate and made it about equal in brilliance to the front of the field. A daylight-blue glass filter partially covered the end of the light-pipe at the source of illumination, and helped to match the inside and the outside of the field in respect to hue.

This experiment also required the use of a headrest for the subject, and careful calibration of the stimulus field with the aid of an engineer's transit.