An Analysis of the Relationship Between Tactual and Visual Perceptions

by

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I. History

The history of psychology has harbored but few doubts regarding the qualitative specificity of sensations and the discreteness of sensations supposedly conditioned exclusively by different sense organs. Classifications of sensory modalities have been based altogether upon corresponding sense organs and sensory qualities. The result has been that the history of psychology is marked by much greater success in the process of reducing sensory consciousness into small sensory units, than in erecting a theory of how these same units become organized into a continuous, dynamic consciousness.

Aristotle, in his Sensus Communis, made a mystical attempt to explain how sensory experiences regarded as discrete entities were utilized in a conscious whole. However, his doctrine of the 'common sense' did not truly account for a structural unity, and only provided a questionable functional whole in which the sensory parts were incorporated.

The doctrine of association lent itself well to the concept of the 'common sense' with the result that it was not until the appearance of Hagen's works that a dissent was heard against the partite sensory composition of consciousness. Hagen suggested that the normal consciousness was visual and that all perceptions were made in terms of this modality.

The doctrine of local signs, by Lotze, and the methodology of Fechner, which was continued by Wundt, added a great superfluity of proof to the belief in discrete sensory qualities. It was not until the time of Pillsbury, Judd, Washburn, and Parrish, who did their work in the laboratory of Wundt on the influence of vision on tactual perceptions that any evidence to the contrary was produced. These four studies failed entirely by using different methods to separate visual processes from those of touch and kinaesthesis.

All during the nineteenth century cases of synaesthesia had been reported but since they were described and explained in the terms of association which assumed that the synaesthetic sensation was a secondary process accompanying the primary sensation, the validity of the primary sensation was not challenged.

Stratton, in his experiment on the effects of retinal inversion found that the perceptions primarily of touch and kinaesthesis were inextricably bound up with that of vision, His results furnish more evidence than he himself saw, that vision was not only the stronger but apparently the only awareness of the primary processes. However, through his adherence to the doctrines of local sign and association he was unable to make any use of these valuable observations. These unemphasized results of Stratton are confirmed in the work of Brown and Wooster.

Benussi, in 1913, was able to demonstrate apparent movement in the sensation of touch. Later Burtt was able to verify Korte's laws in the tactual modality. Since then numerous studies have been made which emphasize different phases of apparent movement. In all of these instances the importance of visual processes for apparent movement can hardly be ignored.

Wheeler and Cutsforth have shown that synaesthesia does not consist of a dual process in which the 'secondary sensory' experience is an associative concomitant of the 'primary sensation.' The synaesthetic process is all that exists in the experience and without that no experience would be possible. The undifferentiated 'parent process' is all that exists of the primary sensation and that does not even possess awareness of quality. It is merely a cognitive reference, a 'pretemporal' awareness.

In 1920 Gelb and Goldstein reported the case of a soldier suffering from a gunshot wound in the occipital region. The patient lacked visual memory and complex visual perceptions.

In 1929, Förster reported a study on mirror learning in which it was shown that motor learning depends on visual learning.

II. Apparatus for all Experiments

1. A graduated series of eight basswood cubes polished and stained a walnut brown were glued at equal intervals on a piece of gray cardboard six and one-half inches by thirty-two inches. At the small end of the series the cube was one cubic inch and the other cubes increased in size by one-eighth of an inch until the largest at the opposite end of the series was one and three-quarter inches square. Accompanying the series were duplicate cubes corresponding to those in the middle of the series. These latter were unmounted.

2. A series of eight basswood parallelograms one-half inch thick and three inches on the sides, polished and stained a walnut brown, were mounted in order of squareness upon a gray cardboard six and one-half inches by thirty-two inches. The parallelograms were equally spaced upon the cardboard and rested with their short axis along the long axis of the cardboard. The series commenced with the narrowest figure whose acute angles were fifty-five degrees. Each figure increased in the direction of squareness until the eighth figure was a perfect square. There were also several unmounted duplicate figures which corresponded with figures in the series.

3. Duplicate sets of five brass rods five mm. in diameter were cut, to form a series, with intervals of one cm. in length. The series advanced from a rod ten cm. long.

4. Five pieces of brass wire screening, three inches square, were mounted upon a piece of one-half inch pine board three inches wide and fifteen inches long. The binding was Manilla tagboard and white library tape. The five squares of screening formed a series in a scale measured by the number of meshes to the linear inch. They were, respectively, sixty, fifty, forty, thirty and twenty meshes per inch. Screens duplicating the series were fastened separately on three-inch squares of cardboard and bound in library tape.

5. Three basrelief figures one to two mm. in thickness were cast upon dental plaster of Paris slabs 15 mm. thick by 145 by 105 mm. Both the figures and slab bases were shellacked heavily to give a smooth non-granular surface. The first figure (X) was that of a leaping fish, 10 cm. in length and varying in width from one to five cm. The figure of the fish was properly orientated to the observer when the head was either pointed to the right or upward.

The second figure was a relief of a nude human being 10 cm. in length. The vertical position was the only correct orientation for the figure of the human.

The third figure was the dorsal view of a frog, 10 cm. in length, stretched out as in diving. In any position, the figure of the frog was properly oriented to the observer.

6. An apparatus was designed for the construction of visual equivalents of standard tactual forms. This apparatus

consisted of a screen for the hand and a vertical exposure-board. The screen for the hand was made of a one-half inch pine board ten inches wide and twenty-eight inches long. The board was mounted upon the end of a laboratory table on two one-half inch board legs ten by six inches long. The opening between the table and shelf-like screen was covered by a black cloth hung from the shelf. At the back edge of the screen-board was a second pine board mounted vertically upon iron rods clamped to the table. The vertical board was covered in front with white tagboard upon which was glued in a central position a polygon in black paper. This figure had a baseline of eighteen inches running from right to left and at the left end a vertical altitude of three-quarters of an inch, while the right end had a vertical altitude of three inches. Suspended from the top of the exposure-board were two white tagboard curtains which slid freely either to the right or to the left so that, when desired, the tactual form could be reproduced visually by a sector of the black surface. A polygon of the exact size and shape of the black figure was made from one-half inch pine, and cut into segments of varying widths. These segments were glued to gray cardboard bases six inches square. Across the front of the exposure-board ran a millimeter scale. A second millimeter scale faced the vertical edge of the left curtain. Thus height and width measurements could be taken off any sector of the black-paper polygon.

7. An apparatus for the purpose of representing visual judgments of tactual sizes consisted of a hand screen and a vertical board on the front of which was an adjustable diaphragm. The hand screen was made of a one-half inch pine board ten by twenty-eight inches. It was mounted six inches above the twenty-eight inch end of a laboratory table upon two one-half inch pine boards ten by six inches. The front opening was covered, with the exception of ten inches at the right, by a black cloth curtain hung from the edge of the screen. At the back edge of the screen-board, mounted on rods and clamped to the table, was a second pine board one-half inch thick by twenty-eight by ten inches. An adjustable diaphragm was constructed upon the vertical board by covering it with a piece of black cardboard set out one-half inch from the surface of the board. The aperture in the black cardboard front exposed a rectangle of white tagboard sixty by forty mm. Between the black front and back-board was inserted a sliding diaphragm which would shut off all the white background from the left. Also back of the black front and in front of the sliding diaphragm was inserted a black cardboard curtain which shut off the aperture from the top down. The vertical diaphragm operated on a slide which was manipulated by the left hand in trombone fashion. The diaphragm coming down from the top was mounted upon a sliding carriage which was manipulated by being made higher or lower by a crank also at the left end.

Attached to each diaphragm and extending through the back-board through slots were pointers which moved along millimeter scales. Readings of the adjustments could be taken off the scales by the experimenter from the rear. The scales and experimenter were hidden from the observer.

Three inches back of the curtain on the front of the hand screen a sheet-metal card-holder six and one-half inches square was tacked to the table top. Immediately back of the horizontal card-holder was a similar card-holder mounted vertically on a wooden frame clamped to the table.

Five rectangular wooden figures were cut from one-half inch triple pine veneer in the following dimensions: No. 1, 120 x 80 mm.; No. 2, 90 x 60 mm.; No. 3, 60 x 40 mm.; No. 4, 45 x 30 mm.; No. 5, 30 x 20 mm. These blocks were mounted upon separate cardboard squares six and one-half inches by six and one-half inches that slipped into the metal card-holders.

One white tagboard rectangle sixty by forty millimeters was mounted on a six-inch square of black cardboard to which were attached wire hooks so that it might be suspended from the top of the diaphragm adjacent to the aperture.

III. Preliminary Experiments

Prior to the adoption of the procedure finally employed in this investigation four preliminary methods and a total of fifty-one subjects were used. Although the preliminary studies produced quantities of positive material and furnished considerable insight into the nature of the problem it was necessary to abandon each, successively, due to some inherent defect within the method. All the preliminary methods employed concrete stimuli to be judged in relation to other concrete objects with the result that it was impossible to control the factor of learning the range of the series of standards. This learning caused judgments to be rendered in terms of the entire series or in terms of previous judgments.

Three of the four preliminary investigations were conducted in a dark room under constant illumination of a one hundred watt incandescent lamp above and to the back of the subject. The fourth was conducted in daylight with the subject seated with back toward a large high window.

In the first preliminary study the subject was seated in front of the table and hand-shield, in an ordinary chair. He was presented with a series of cubes, parallelograms, wire screening, and brass rods, under the shield with instructions to examine them tactually. More definite instructions were purposely avoided. Upon becoming familiar with the varying degrees of size, shape, length or form of members of a particular series he was presented with a unit of the series, visually, and asked to indicate which unit of the series corresponded to the visual standard.

The second procedure consisted of reversing the method of presentation used in the first. The subject was given the series to view visually and then was presented a tactual unit from the series and asked to indicate which one of the visual series corresponded to the tactual unit.

The third method consisted of presenting the subject with one isolated unit tactually, then another unit visually, under instructions to judge which of the two was the longer, the shorter, or whether they were equal.

In the fourth preliminary method the subjects were presented with a wooden polygon to be examined tactually under the hand screen. They were asked to adjust the sliding diaphragm on the apparatus until the exposed figure of black cardboard was of the same size as the tactual polygon. The tactual polygon was presented horizontally in such a manner that it would correspond with the visual segment which was in a vertical position. The subjects were given unlimited time in which to form their judgments.

It was found in the first preliminary method that there existed a considerable discrepancy of judgment for each observer in the first few trials. However, as the number of trials increased, this discrepancy in size between the tactual and visual judgments tended to disappear. The subjects themselves reported that the first few trials were the most difficult and especially the very first one. At the outset some of the observers made their visual judgments larger than the corresponding unit in the tactual series while others reversed the difference. No matter in which direction the discrepancies occurred, observers learned quite rapidly to make relatively accurate judgments. This held in all the preliminary series with cubes, screens, rods, and parallelograms.

It was found that the wider the range of visual standards, the sooner the observers acquired an ability to make accurate judgments. It was quite evident that all opportunities were taken advantage of in order to increase the observer's insight into the relative size of the tactual series. Thus, when the first few judgments were made, the relationship between the visual standard and the tactual units were discrete, and the series possessed no unity. The first few judgments by necessity were formed in terms of highly rational processes, for no size relationship between the two objects were perceptible to the observers. Later, however, these same rational processes were employed in unifying the tactual series, so that it was possible to transpose up and down the series with ease. In fact some of the observers were able to make accurate judgments of equality without examining the tactual series. All sorts of rational devices were employed to reconcile the size or form of the visual standard with some corresponding unit of the tactual series.

By rational comparisons is meant that the observer noticed an inevitable discrepancy between the tactual object and his first estimates of its size in terms of the visual reproduction. He also noted how at one time he was tempted to make the visual figure larger than he felt it ought to be, and at another time smaller. But he was quick to observe that there were no definite perceptual criteria by means of which to correct the discrepancy which ranged from fifteen to twenty percent of the size of the tactual standard. Then he set about to learn the tactual series as a whole and to make his visual judgments in terms of the whole, which he could eventually do with considerable accuracy.

However, since we were studying discrepancies in visual-tactual judgments in the seeing for the purpose of comparison later with tactual judgments of the adventitious and congenital blind who have no rational criteria by means of which to correct their errors, these corrections were spoiling the experiment.

A reversal of the procedure used in the first method proved less satisfactory than the original. With the series of objects, cubes, rods, etc., placed in view of the subject for visual observation, the learning of the series was much more rapid and complete than when it was used as a series of tactual stimuli. However, as was the case in the first method, there existed a considerable discrepancy between the judgments based on tactual exploration and those based on visual observation. The observers made characteristically larger or smaller judgments corresponding to their particular point of reference, that is, to whatever they employed as the standard. An observer who overestimated a cube in the first method when the visual cube was the standard, would reverse his judgment under the second method by using the tactual object as the standard. There existed individual differences among observers in choosing between the visual and the tactual object as a standard. Some chose one; others chose the other. In some cases the figure grasped in the hand was the determining factor in making the tactual object the standard of reference, while with others the visual object held a relational dominance for the observer. This is not only borne out in the reversability of the judgments but also in the introspective reports.

It turned out, as will be emphasized later, that when an observer had made his judgment and had either overestimated or underestimated the size of the tactual object in matching the visual figure to it, he perceived apparent movement of the tactual object when the latter was brought into view. This fact, incidentally, proved that visual processes dominated the judgment, for, when the tactual object was shown the observer, it looked either too large or too small and expanded or shrank to fit his visual judgment of its size.

An observer whose judgments were dominated by tactual-visual experiences, that is, by the tactual object as the standard, could not perceive apparent movement unless it occurred in terms of visual and perhaps kinaesthetic imagery of the block-hand situation. An observer whose dominant point of reference was the visual object could perceive apparent movement in the expansion or contraction of the visual pattern at the aperture, a movement that was conditioned, curiously, by a changed judgment of the tactual object, in turn conditioned by hand movement. In other words, a correction of the discrepancy in size between the tactual and visual object may come about either as a change in the tactual object or a change in the visual figure, and this change may occur slowly enough to be perceived as apparent movement.

The third preliminary method was devised in order to avoid the influence of learning. However, the presentation of discrete units to be judged as greater than, equal to, or smaller than, proved no more successful than the previous two methods. The observers not only continued to learn the series but also became strongly influenced by the memory of the judgment just previously made. With the exception of the first judgments it was impossible for the observers to make an absolute judgment, for upon the presentation of the second set of comparative material they employed a relative judgment using the previous set or range of previous sets as a point of reference. In fact, not all first judgments were absolute by any means, for it was reported by a great many observers that there was a rational attempt to compare the tactual object with some visually familiar size, shape, or form. Thus, one observer, when a pair of screens was presented to him for the first time, judged the tactual screen not in terms of itself or in reference to the size of the meshes in the visual screen, but in terms of a tactual-visual memory-image of ordinary wire window screen and from this as a point of reference he gave his judgment. Likewise, rods were judged in terms of finger lengths and breadths, cubes in terms of the extent to which they filled the visualized hand, parallelograms by length and breadth as visualized upon the hand, etc.

The fourth preliminary method which employed the apparatus for the purpose of reproducing the bi-dimensional size of the tactual standard was also abandoned. The chief difficulty of the method lay in the nature of the form of the tactual objects which were exact duplications of segments of the black cardboard pattern. Since the visually continuous pattern possessed a slanted line along the top edge, all the segments also would possess a segment of the same angle. It was found that the tactual perception of the subjects was not sufficiently acute to detect the top edge of the tactual figure as a slanting line with the result that all of the tactual figures regardless of their size were perceived as rectangles. It was found in the case of two hundred judgments given by twenty naïve observers that the lack of discrete units in the series tended to illiminate the effect of previous learning. There was a decided tendency to make the judgments smaller in the upper end of the series and larger in the lower end of the series. Throughout there was a strong tendency to make the reproductions symmetrical. That is, the narrow figures wider and wider figures taller than they were tactually.

IV. Main Experiments

The investigation proper was divided into two parts. The first was performed with a group of ten trained observers made up of ten male members of the staff and graduates from the department of psychology. The second group consisted of naïve observers--girls and boys from the elementary laboratory classes.

The experimentation was performed in a dark room under the constant illumination of a one hundred watt incandescent lamp. The trained subjects made fifty-two judgments at each of six sittings held not less than seven days apart and not more than twenty-one days. The naïve group served as observers but once during which sitting they made fifteen judgments.

The observer was seated in an ordinary chair in front of the apparatus with the adjustable diaphragm, so that it was convenient and comfortable for him to employ his right hand in the act of examining the tactual object held in the card-holder and at the same time manipulate the diaphragms with his left hand. His position brought the center of the diaphragm in the center of the field of vision. A one hundred watt incandescent lamp illuminated the front of the diaphragm from a position back and above the observer. The observer was asked to examine the figure back of the black curtain with his right hand tactually, and when he had perceived the size of the figure, to reproduce it by adjusting the diaphragm until an area of white tagboard was exposed which duplicated the tactual figure. This procedure was employed with both the trained and naïve observers.

The trained observers were divided into two groups of five each. At the first sitting the members of the first group of five observers made two judgments which were purely visual. They were asked to reproduce upon the diaphragm the perceived size and form of a white piece of tagboard 60 by 40 mm., glued to a six-inch square piece of black cardboard hung upon the front of the diaphragm just at the right of the aperture. This judgment they made both at the beginning and at the end of the sitting. Then they were asked to make reproductions of the tactual figures which consisted of ten series of five rectangles in the order as given, 120 by 80 mm., 90 by 60 mm., 60 by 40 mm., 45 by 30 mm., 30 by 20 mm. During the first sitting of the first five trained observers these series of figures were presented in a horizontal position with the long axes running north and south map-wise. Also at the first sitting the first five trained observers perceived the tactual figure by a method of passive touch, that is, of placing the hand and fingers upon the figure without making exploratory movements. This will be called the Horizontal Passive procedure (H.P.).

In the second sitting of this group the observers employed only exploratory movements of the index finger about the edge of the figure, the Horizontal Active (H.A.) procedure.

On the third sitting the observer was permitted to employ any method which suited his own personal procedure of tactual examination; the Horizontal Voluntary (H.V.) procedure.

On the fourth sitting the figure was changed to a vertical position with the long axis of the figure running up and down. On the fourth, fifth and sixth sittings the methods of tactual perception were repeated in order as in the horizontal position. These are to be called the Vertical Passive, (V.P.), Vertical Active (V.A.), and Vertical Voluntary (V.V.) methods.

With the second group of five trained observers the procedure varied only in that the first sitting started the first of the vertical positions and the fourth started the first of the horizontal positions.

The one hundred and twenty naïve subjects were divided into four groups of thirty. Each group made two visual judgments using the white visual rectangle and each judged two series of five rectangles in one of the four methods H.P., H.A., V.P., and V.A. Group one made their judgments with the tactual object in a horizontal position employing the passive method of tactual perception (H.P.). The second group of thirty observers employed the horizontal position of the tactual object using active finger movement of the index finger about the edges of the figures (H.A.). The third group of thirty observers perceived their tactual figures in a vertical position by the static hand method (V.P.), and the fourth group of thirty observers also employed the vertical position of figures, but with exploratory movement of the index finger. (V.A.).

Three additional judgments were made by the naïve observers. In the horizontal card-holder was placed, in order, a cube, parallelogram, and a square of brass screen. The observer was instructed to examine the object with care, tactually. Then he was presented, visually, with a series of like objects, varying in size, as in the preliminary experiments, and asked to indicate the object which corresponded most closely with the one which he was exploring tactually.

V. Results

Part One

Judgments of Visual Size The ranges of judgments of height and width by both trained and untrained subjects show a surprising inaccuracy in matching one visual size with another visual size. The curves of distribution in Plate I show the extent of inaccuracy in these judgments both for trained and untrained observers. The distribution of judgments for height, in case of the trained observers extends from 55 to 67 mm., a scattering of 12 mm., or 20 percent of the standard height. The mode occurs at 59 which is one point below the standard height. The untrained observers make a much greater scattering of their judgments of height by extending the range from 50 to 68 which is a range of 30 percent of the height. The judgments of height for the untrained observers form themselves into a bimodal distribution with the points of most frequent judgments falling at 56 and 60.

Also in the judgment of widths the trained observers scattered out over a smaller range running from 37 to 47, with a mode at 42. The range, which represents 40 percent of the standard width, falls <u>for the most part above the standard</u>. The untrained observers scattered their judgments over a range of which is equal to forty percent of the standard width. The mode occurs at the same point as does

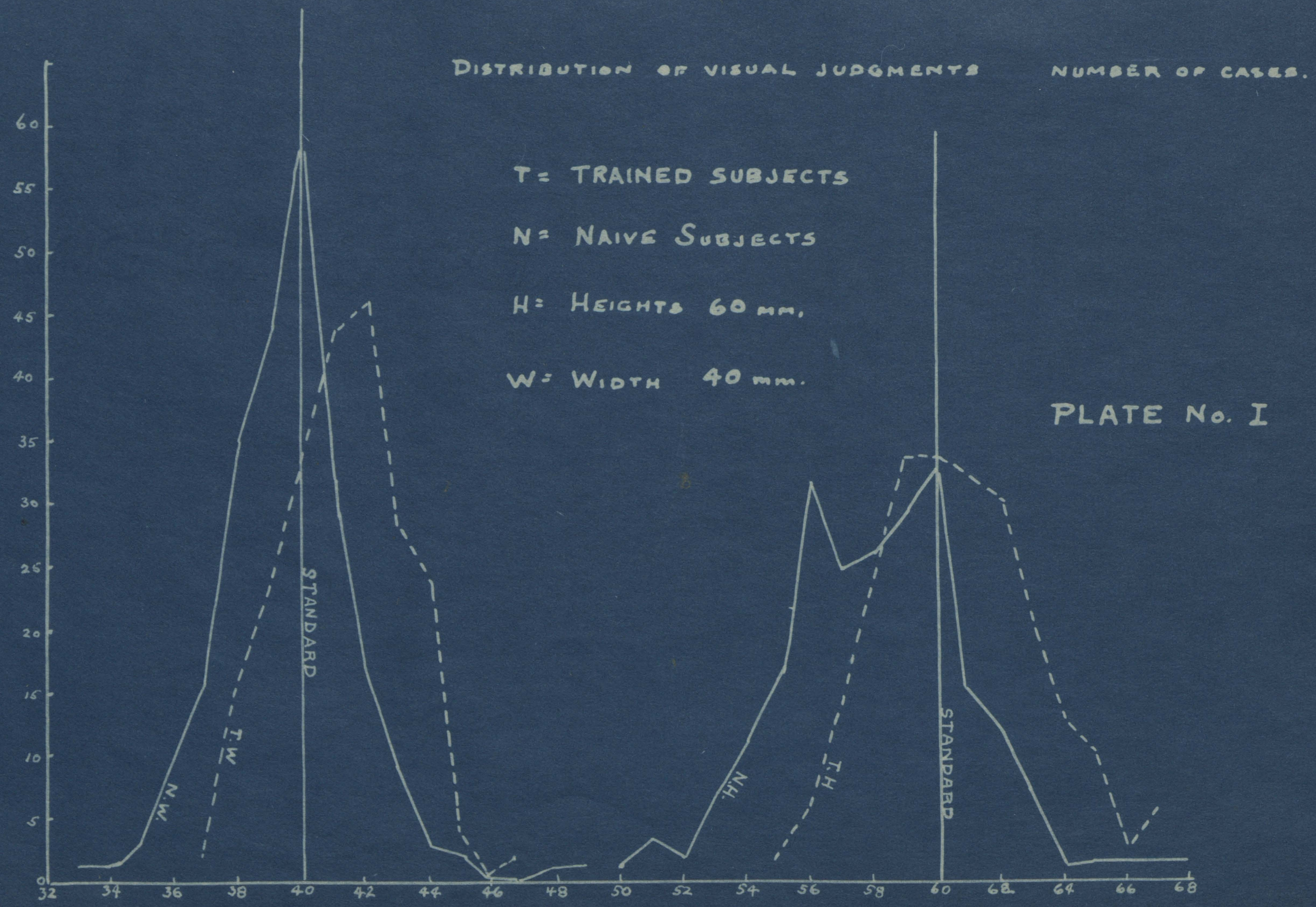

DISTRIBUTION OF VISUAL JUDGMENTS
NUMBER OF CASES.
T= TRAINED SUBJECTS
N= NAIVE SUBJECTS
H= HEIGHTS 60 mm.
W= WIDTH 40 mm.
STANDARD
STANDARD
N.W.
T.W
N.H.
T.H
60
55
50
45
40
35
30
25
20
15
10
5
0
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
66
68

PLATE No. I

the width of the standard but a larger part of the judgments fall below this point. An inspection of Plate I shows that the trained observers are prone both in their judgments of height and width to over-judge the standard. The untrained observers show a decided tendency to distribute their judgments below the standard.

It is quite significant for the problem of perception, that the visual sense, with its high degree of acuity in the perception of form and extent, should have its precision upset by a 'central' influence, the influence occasioned by the goal of observing a relationship.

Part Two

The Discrepancy Between Sight and Touch A large discrepancy was found to exist between the tactually perceived standard and the matched visual equivalent in the judgments of all the subjects made in all the different positions, with all the different methods employed, and with all the five stimuli.

Tables I and II give the judgments of height and width for all subjects and for all the different sized stimuli for all the different conditions. Tables V and VI include measurements of the extent of the discrepancies. Table VII shows that under-judgments of the tactual standard were made to the extent of 44 percent of its size, and that over-judgments of the standard ran to 47 percent, with an average discrepancy running as high as plus or minus 12 percent for certain of the stimuli. As will be noticed from an inspection of the various Plates with the exception of Plate I, the ranges of distribution are modified by the different positions, methods and standards employed.

Such broad ranges of distribution with their bimodal tendencies definitely indicate that the tactual perception of size is quite unreliable and that it is influenced by a great many conditioning factors. The trained observers were, on the whole, less accurate than the naïve.

Part Three

The Effect of Position on the Discrepancy Between Sight and Touch The horizontal position, tactual standard at right angles with the axis of the body, is conducive to more accurate judgments than the vertical position when the tactual standard is parallel with the axis of the body. The different effects of the two positions can be seen from Tables VI and VII. Table VII shows the discrepancies for height and width for the horizontal and vertical positions separately. These differences do not remain constant for all methods and all sizes, and also vary between observers. The two positions do not so much put the tactual figure into different relation to the perceiving hand as it puts the perceiving hand in a much different relationship to the observer. The two different positions of the hand do not offer the same spatial problems. This fact is more constant for the untrained observers than for the trained, because the trained observers seem to be able to reconcile the spatial relationships of the two positions much more accurately than the untrained. This difference between the horizontal and vertical positions and between trained and untrained observers is revealed not only in the two ranges of judgments which differ in extent, but also in the places along the distribution where the greatest number of judgments fall.

Part Four

Effect of Passive and Active Exploration on the Discrepancy between Sight and Touch

The two methods of examination of the tactual standards--passive, without finger movement, and active, with finger movement--produce different ranges of distributions of judgments. The effect of the two methods is displayed in Tables VI and VII. In Table VII the extent of the discrepancy between the actual tactual standard and the matched visual size is given. The results show that the active method reduces the extent of over-judgments and increases the extent of under-judgments in both the height and width. That is, it tends to shift the range of distribution further below the tactual standard. This effect becomes less apparent on the smaller blocks, and is less apparent for naïve than for trained observers.

The effect of movement upon tactual perception would indicate that tactual space was less apparent during movement than when the hand was in a passive state. The fact that the trained observers exaggerated this tendency as compared with the untrained observers would indicate that the trained observers possessed perceptual equivalents for a less amount of the finger movement than did the untrained observers. The trained observers, also, moved more slowly than the naïve.

It must not be contended that it is possible to separate entirely the effects of the combined influences of position and movement. It can be seen that passive judgments made from a horizontal position are distinctly different from those passive judgments made in a vertical position. Each of the two conditions in combination produce relationships which neither can be held responsible for separately.

Part Five

Influence of Size on Discrepancy Between Sight and Touch It can be seen from Tables V, VI, and VII that size of block exerts an influence upon judgments of tactual size. The chief tendency is to over-judge the smaller sizes relatively more than the larger sizes. This holds throughout for all the judgments by all subjects using the different positions and methods. The interrelating effects of these conditions can be seen in an inspection of Plates II, III, IV, and V. Conversely, the large sizes are

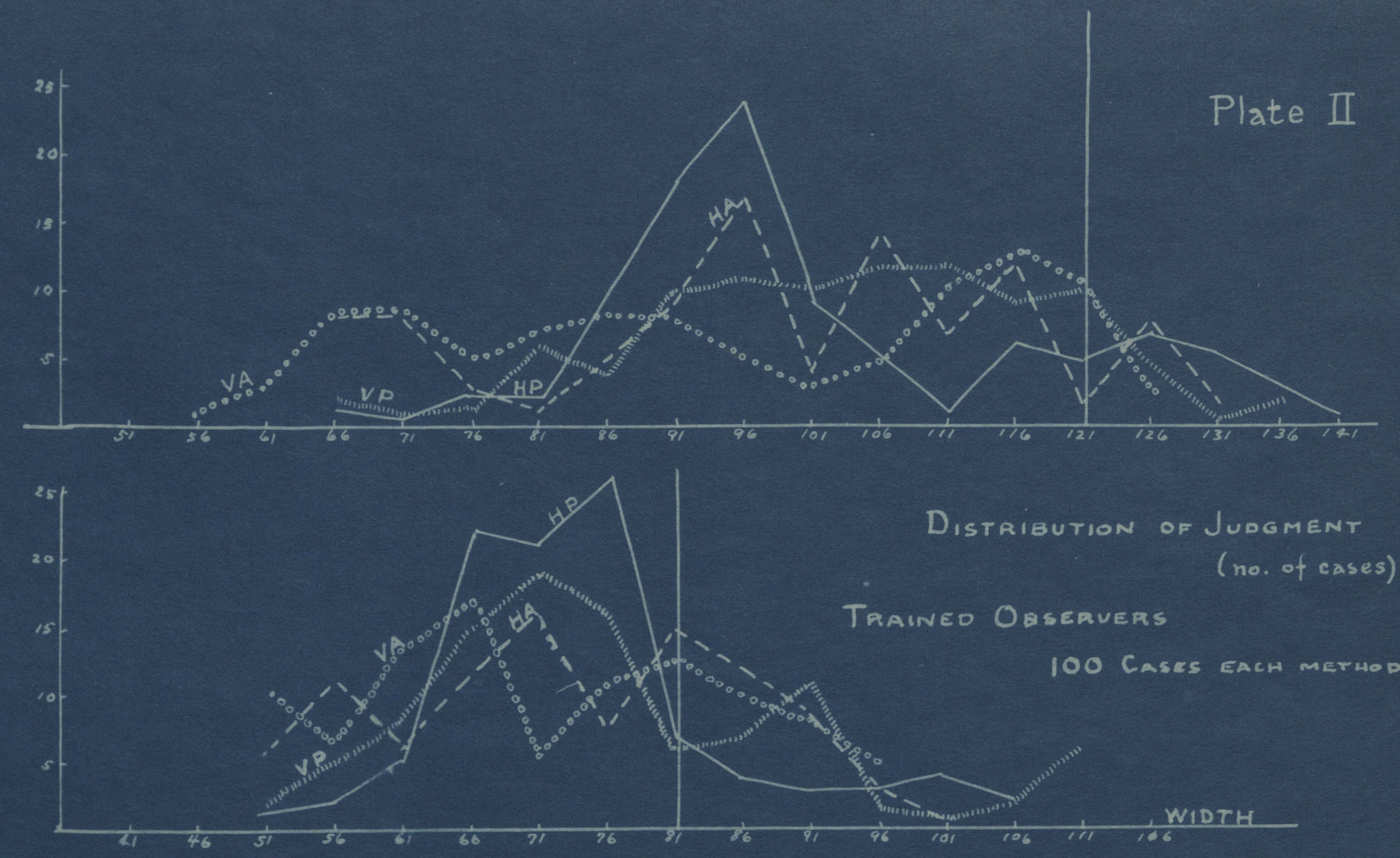


Plate II
Distribution of Judgment
(no. of cases)
Trained Observers
100 Cases each method
VA
VP
HP
HA
WIDTH
25
20
15
10
5
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
126
131
136
141
41
46

Distribution of Judgments - Number of cases

Trained Observers All Methods Combined

400 Judgments

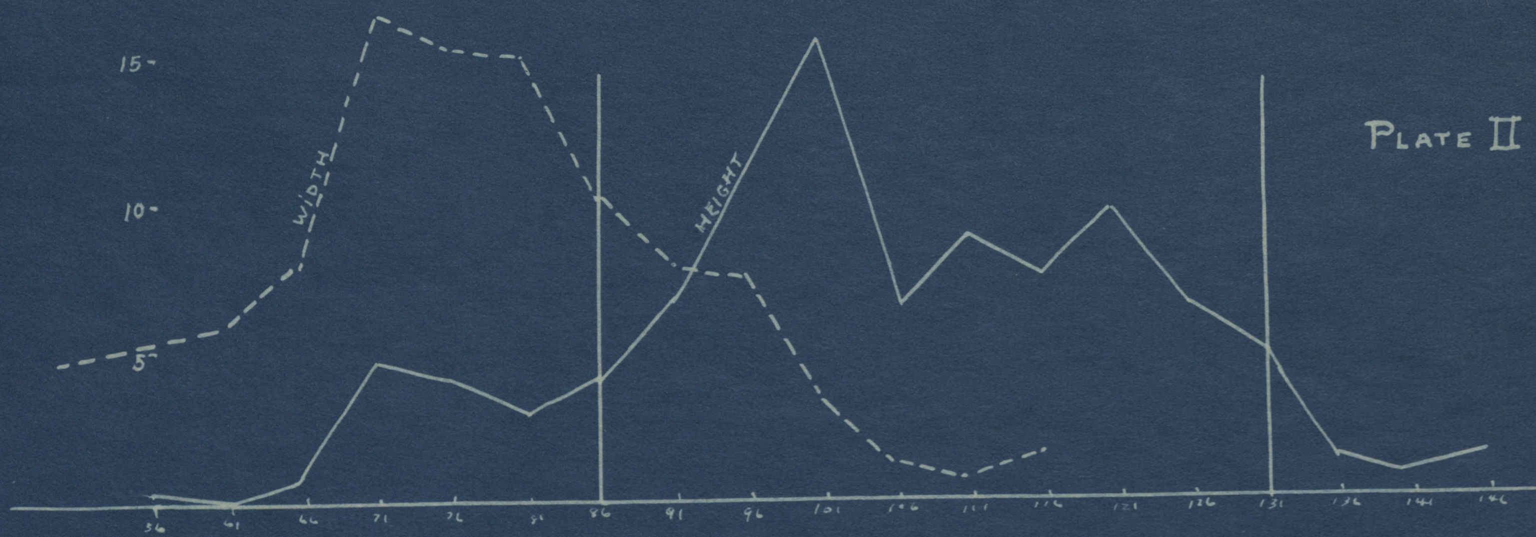
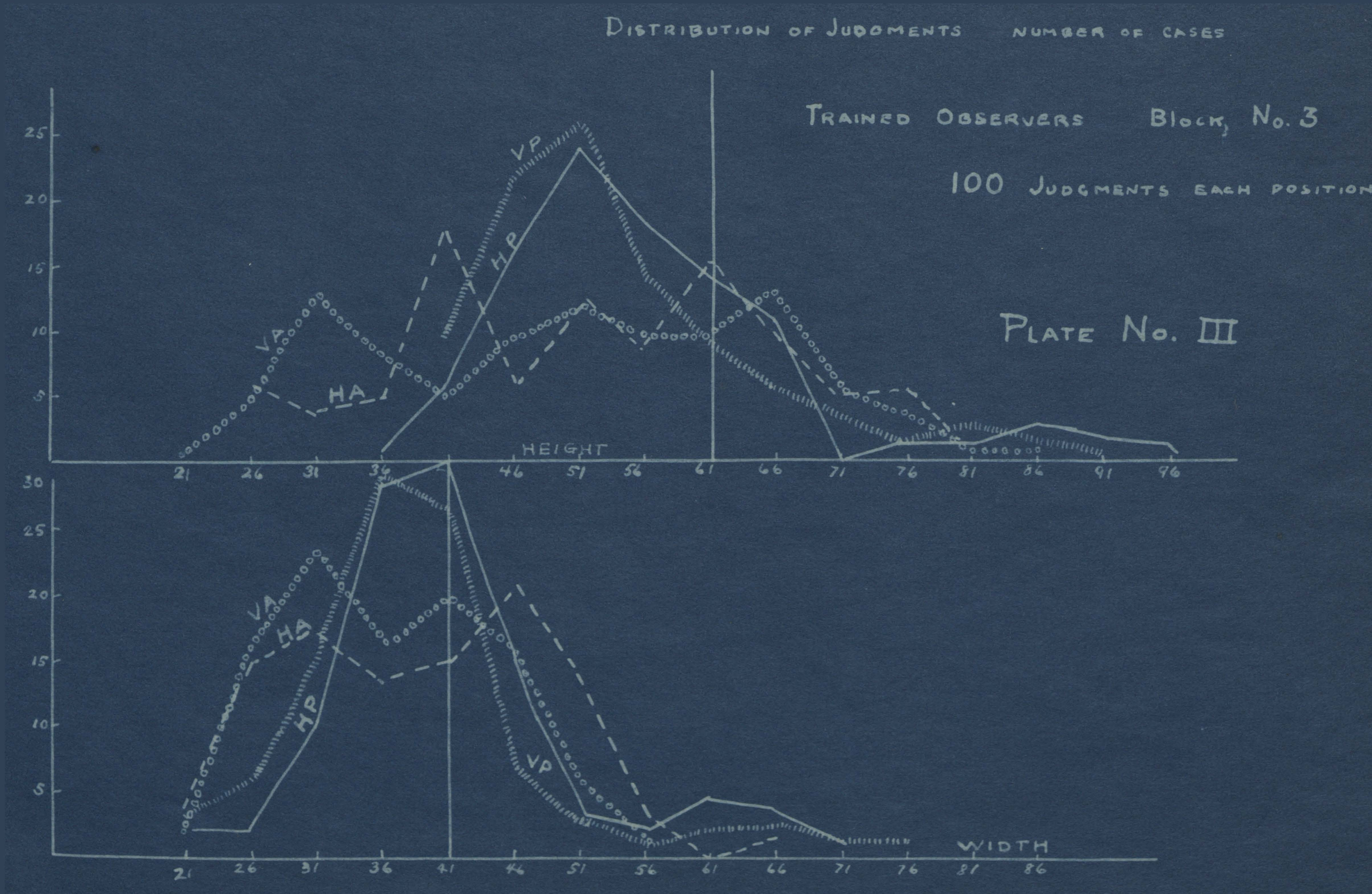
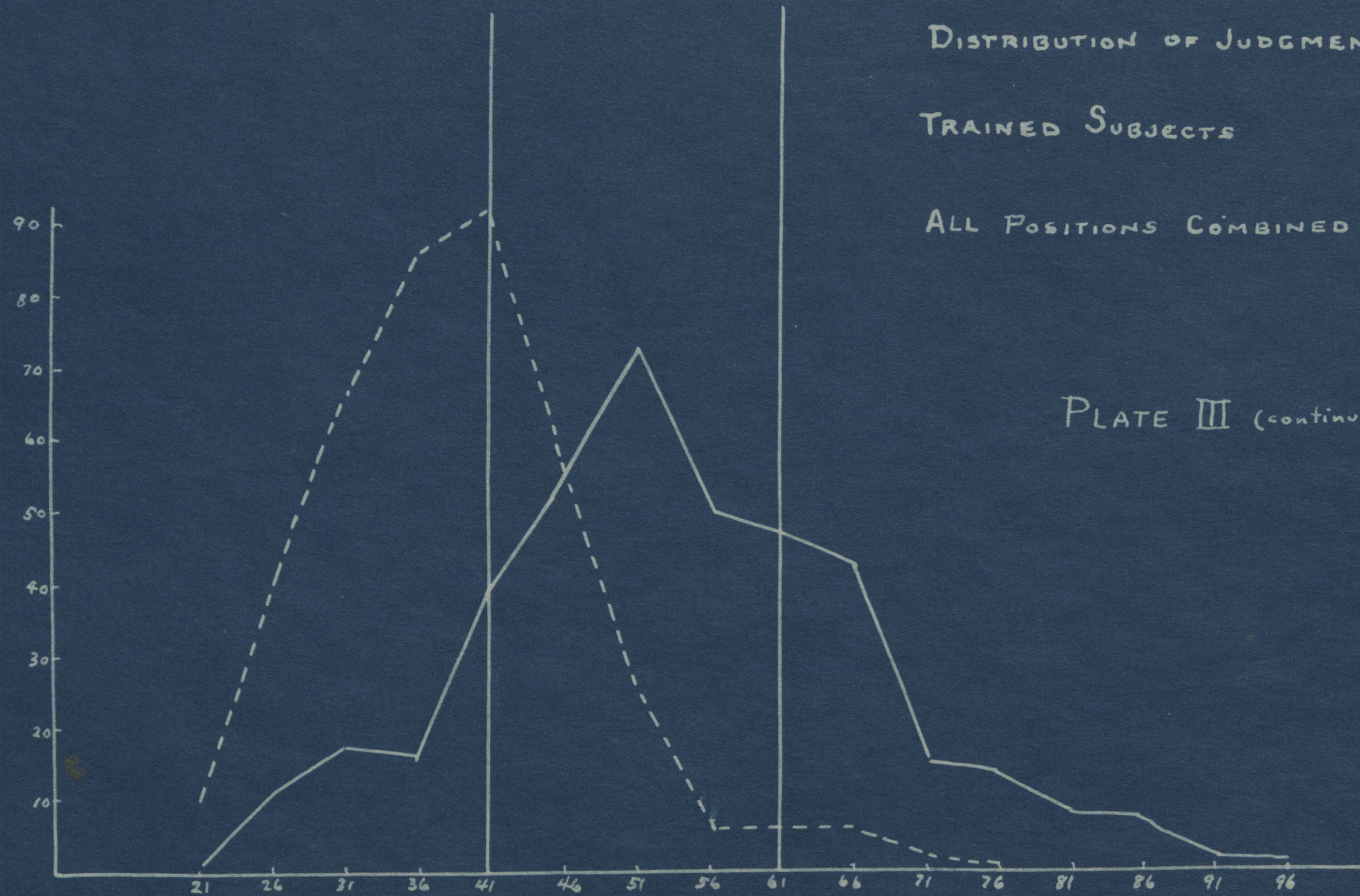


Plate II (continued)


Distribution of Judgments
Number of Cases
Trained Observers
Block, No. 3
100 Judgments each position
Plate No. III
VA
HA
VP
HP
Height
Width
25
20
15
10
5
30
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96

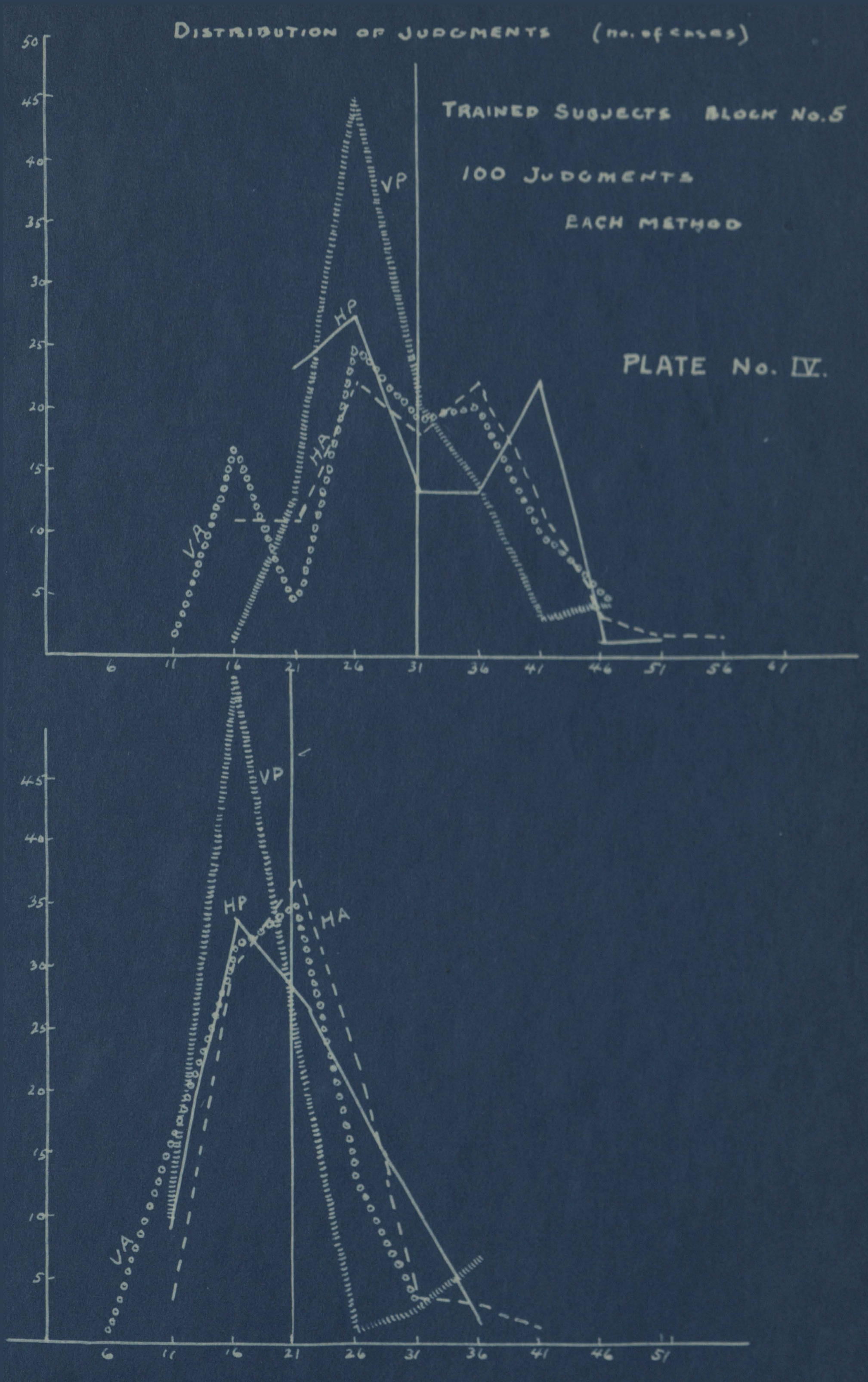


DISTRIBUTION OF JUDGMENTS

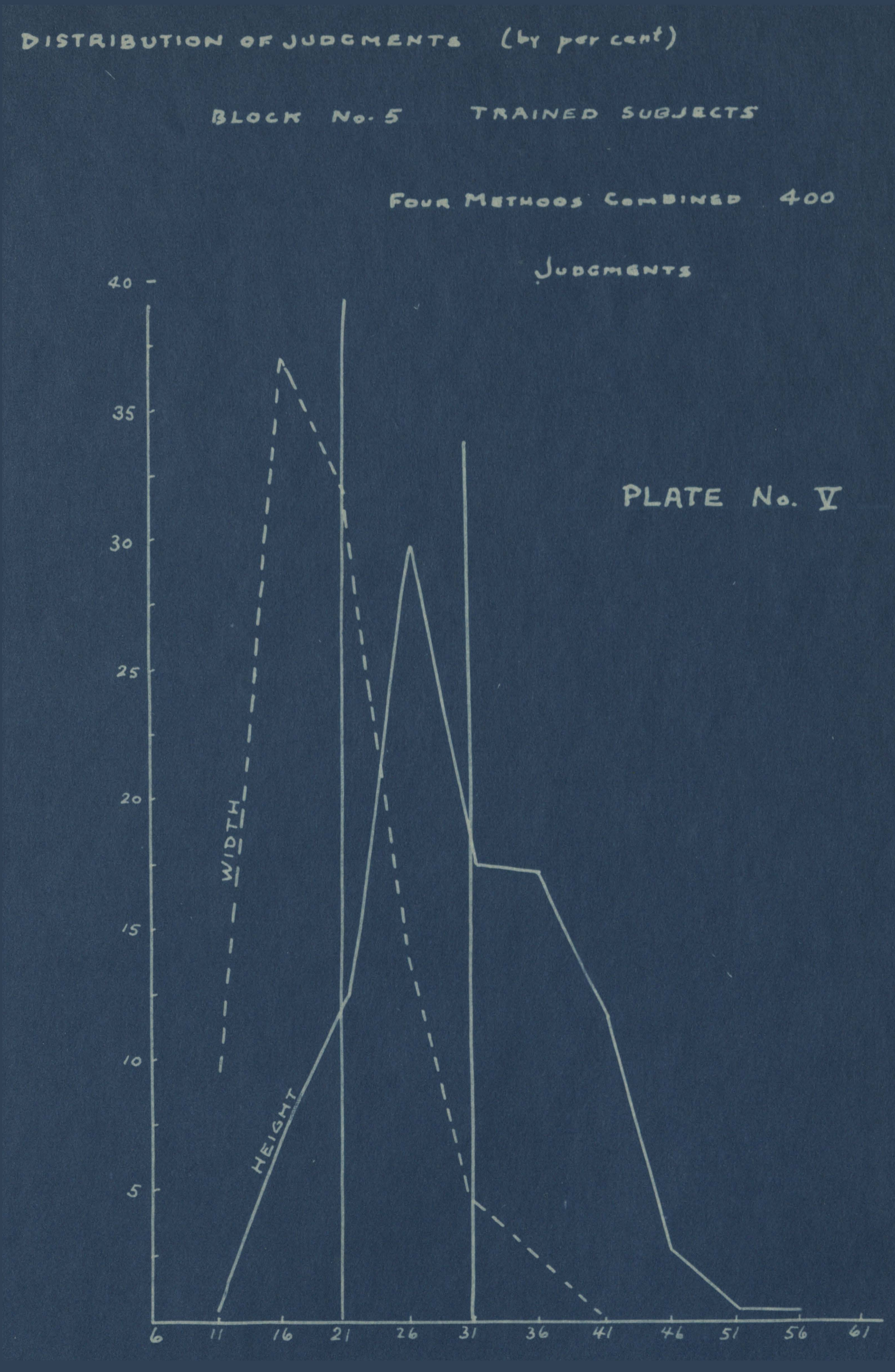
TRAINED SUBJECTS

ALL POSITIONS COMBINED 400 JUDGMENTS

PLATE III (continued)



DISTRIBUTION OF JUDGMENTS (no. of cases)
TRAINED SUBJECTS BLOCK No. 5
100 JUDGMENTS
EACH METHOD
PLATE No. IV.
VP
HP
HA
VA
50
45
40
35
30
25
20
15
10
5
6
11
16
21
26
31
36
41
46
51
56
61


DISTRIBUTION OF JUDGMENTS (by per cent)
BLOCK No. 5 TRAINED SUBJECTS
FOUR METHODS COMBINED 400
JUDGMENTS
PLATE No. V
WIDTH
HEIGHT
40
35
30
25
20
15
10
5
6
11
16
21
26
31
36
41
46
51
56
61

underestimated the most. Naïve observers are slightly less effected by difference in size than are the trained observers. It is interesting to note that the relative distortions of blocks two, three, and four, are about the same, while the extremes, one and five, show the extreme distortions.

Part Six

Symmetry in Purely Visual Judgments Plate I shows that there is a definite tendency, in making visual judgments, to shorten the length and broaden the width of a figure possessing a three to two relationship. This means that there is a visual perceptual tendency to perceive a vertical, rectangular figure of the proportions of three to two in the more symmetrical relationship of a one to one proportion. The importance of this tendency is still more significant in tactual perceptions of form and will be discussed separately in a special section. However, the suggestion may be made here that the perception of visual proportion and form-relationship not only includes the perception of form but also the perception of size as well. Size, of necessity, is a perceptual whole that cannot be constructed from separate judgments of height and width.

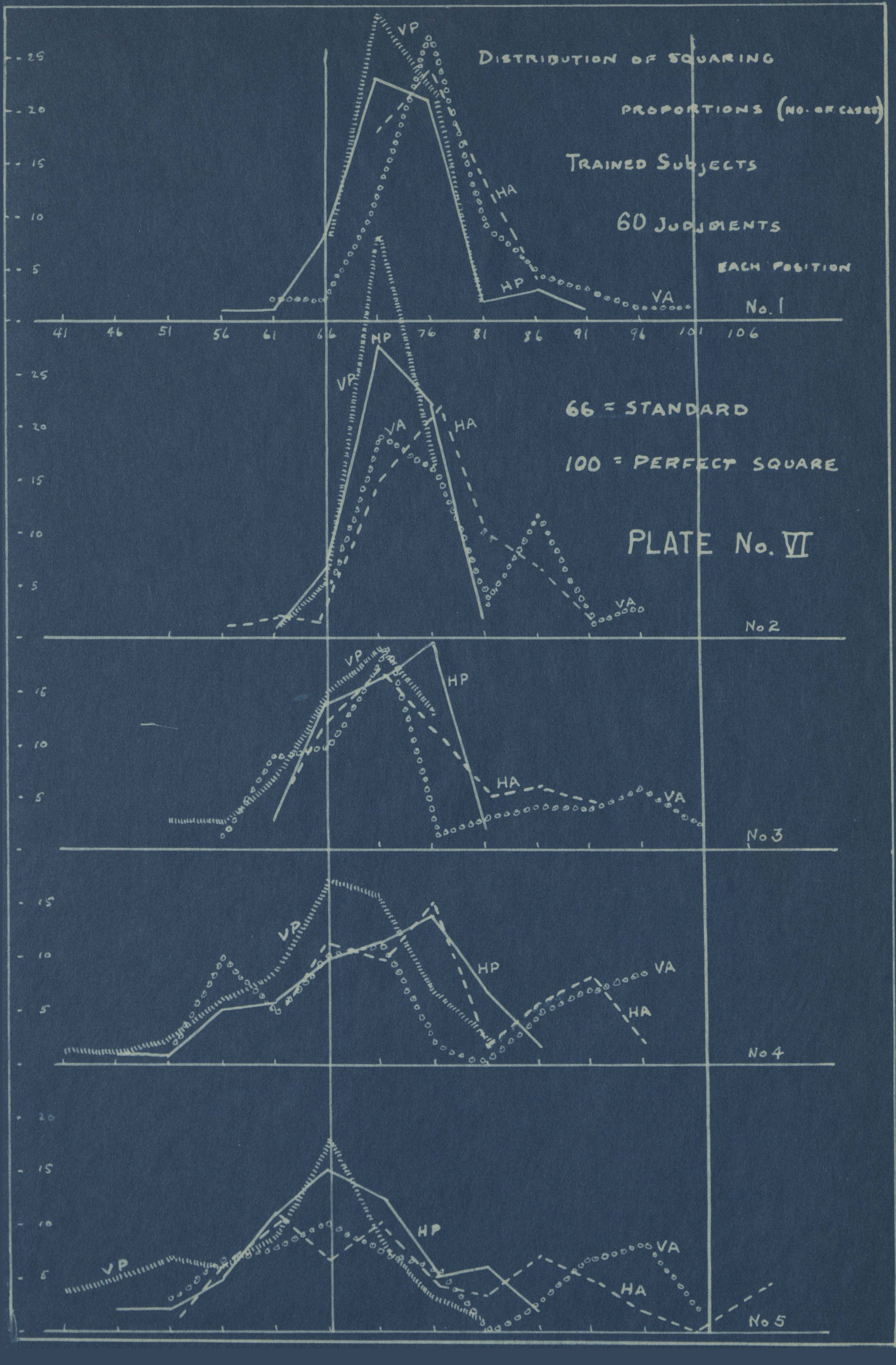
Part Seven

Symmetry in Tactual-Visual Perception A tendency toward symmetry was found in 78 percent of all judgments made from tactual forms. Table VI shows the distribution of squaring of all judgments under all the different conditions. The distribution ranges from 41 to 148 with 66 representing the standard proportion. The mode of the squaring occurred from 71 to 76 (100 represents perfect squaring and any figure over 100 represents the fact that the figure is made wider than it is high). Plates VI, VII, and VIII picture the ranges of squaring graphically.

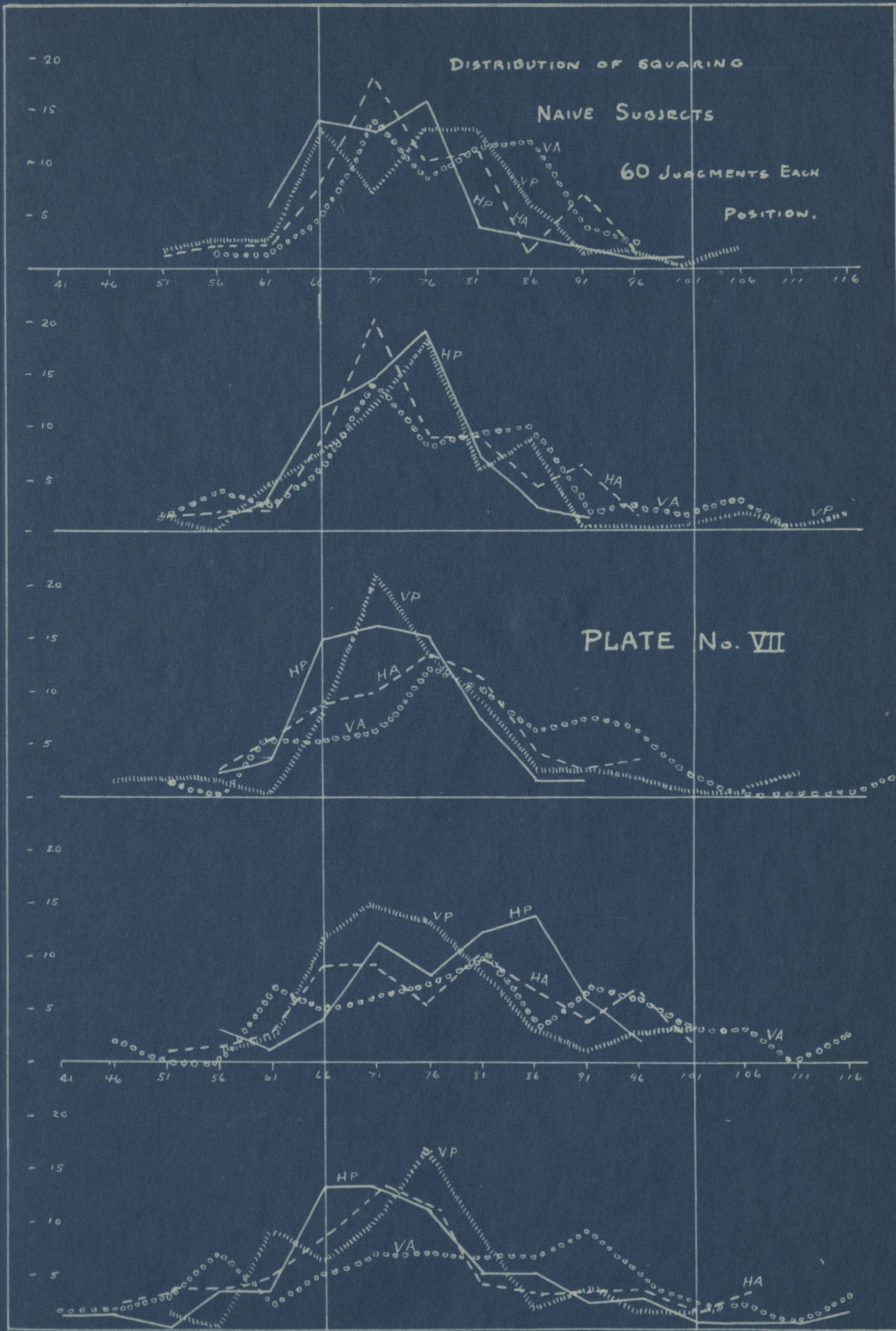
From these tables and graphs can also be deduced the fact that trained observers square less, but on the whole, over a wider range, than the untrained observers.

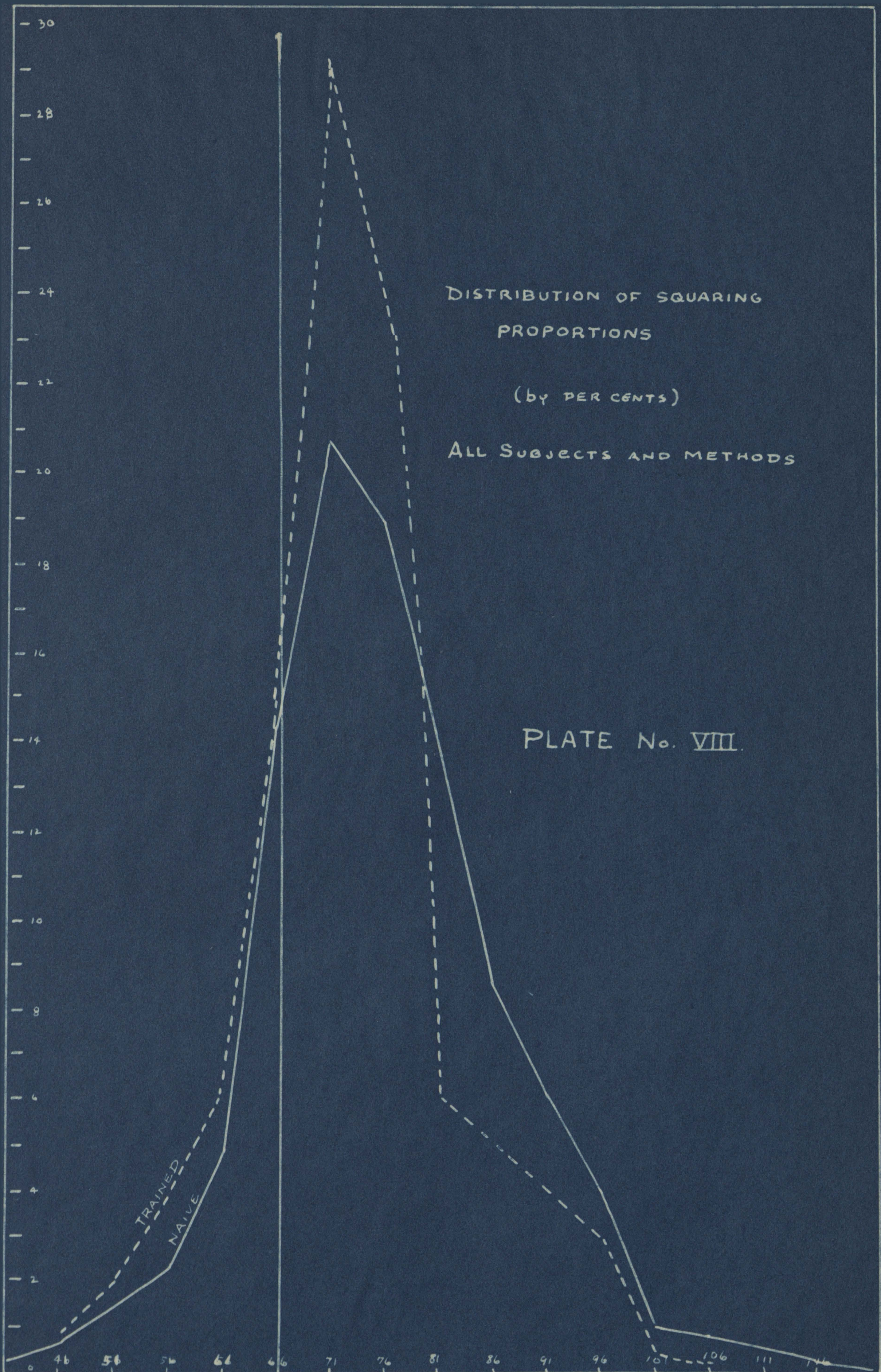
Part Eight

Effect of Position on Symmetry It is difficult to evaluate the effect of position upon the tendency toward symmetry for the amount of squaring done by the two groups varies for position as well as for method. The general tendency toward symmetry due to position shows a slight favoring by the vertical position. The amount of squaring given in Table VII shows that the trained observers, with the horizontal method, square on the average to the extent of 8.5 points and for the vertical, 7.3 points, while the untrained observers on the horizontal position square to the extent of 12 points and on the vertical, 15.4 points, which would make a squaring tendency of 2.2 points less for the horizontal position. However, here again there is found a greater difference between the two groups of observers than



DISTRIBUTION OF SQUARING
PROPORTIONS (NO. OF CASES)
TRAINED SUBJECTS
60 JUDGMENTS
EACH POSITION
66 = STANDARD
100 = PERFECT SQUARE
PLATE No. VI
No. 1
No 2
No 3
No 4
No 5
VP
HP
VA
HA
41
46
51
56
61
66
76
81
86
91
96
101
106


DISTRIBUTION OF SQUARING
NAIVE SUBJECTS
60 JUDGMENTS EACH
POSITION.
PLATE No. VII
HP
HA
VP
VA
41 46 51 56 61 66 71 76 81 86 91 96 101 106 111 116
5 10 15 20


DISTRIBUTION OF SQUARING PROPORTIONS
(by PER CENTS)
ALL SUBJECTS AND METHODS
PLATE No. VIII.
TRAINED
NAIVE
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116

there is between positions.

Part Nine

Effect of Passive and Active Methods on Symmetry The two methods of tactual exploration of the standard had opposite effects upon the tendency toward symmetry. The untrained observers do less squaring when the form is perceived passively and increase the amount of squaring when movement is employed in making the perception. The trained observers do their greatest amount of squaring in the method of passive exploration and decrease the amount of squaring when movement is employed. This shows clearly that neither method possesses an effect inherent in itself but is associated inextricably with other factors. These results seem to hinge upon the facts that the trained observers were too analytical and lost their perception of proportion, especially when making slow exploratory movements.

Part Ten

Effect of Size on Symmetry It cannot be established that difference in size has any definite effect upon the tendency toward symmetry. Table VII will show that the untrained observers tend to square more in the larger figures and much less with the smaller figures, while the trained observers tend to square the smaller figures more than the larger ones. As a generalization it can be said that the extremes in either direction toward the large or toward the excessively small, decrease the tendency toward squaring. Block three shows the greatest amount of squaring, which would indicate that Block three received the combined effects of the trained and untrained. It was the most convenient block to handle.

The opposite effects of size upon the two groups of observers would indicate that other and more subtle factors were operating than differences in actual size.

Part Eleven

Relation of Squaring to Accuracy of Visual-Tactual Judgments It may be concluded in general that those conditions which are conducive to accurate judgments of size are also conducive to squaring. These conditions are not constant throughout the entire investigation nor do they apply equally to both groups of observers. Already it has been shown that the observer himself is an important and neglected factor among the conditions under which the judgments are formed. The different positions, methods, and sizes of blocks cannot be regarded as separate and distinct conditions of judging as such, but only as separate conditions in relation to the observer's procedure.

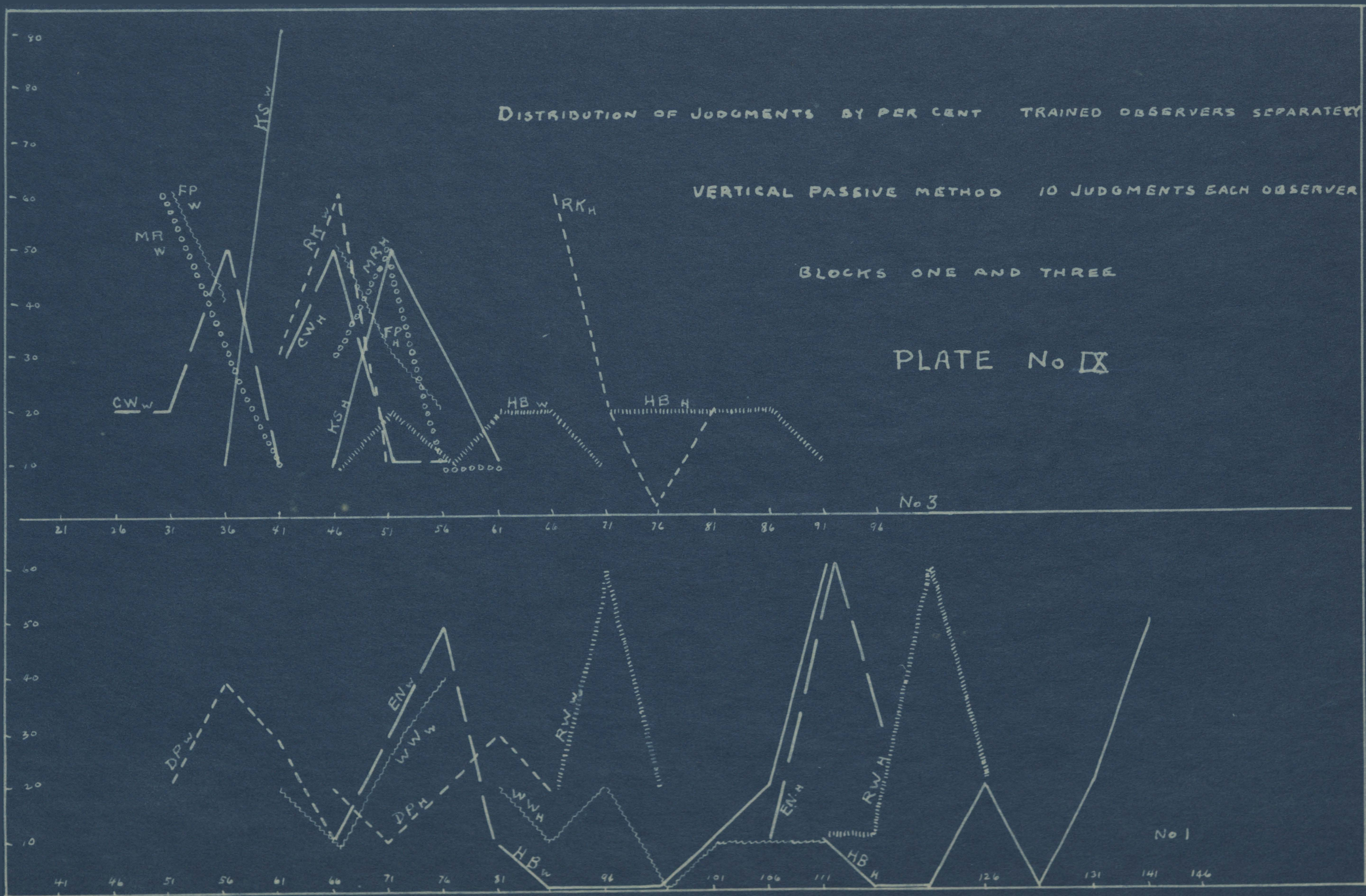
The relation of the range of judgments of height and width to the actual height and width shows to what extent the figures are broken up and analyzed, especially by the trained observers. The discrepancies between these judgments and actual height and width of the three blocks one, three, and five show how the two factors of accuracy and squaring are related. In block one the average judged height is 74 percent of actual height, width 94 percent. In block three the average height is 120 percent, and width 137 percent. In block five the average height is 150 percent, width, 150. In block three accuracy and squaring are at their maximum while in block one both accuracy and squaring are less. Finally, in block five both the accuracy and squaring are still less in virtue of a 50 percent discrepancy in both height and width.

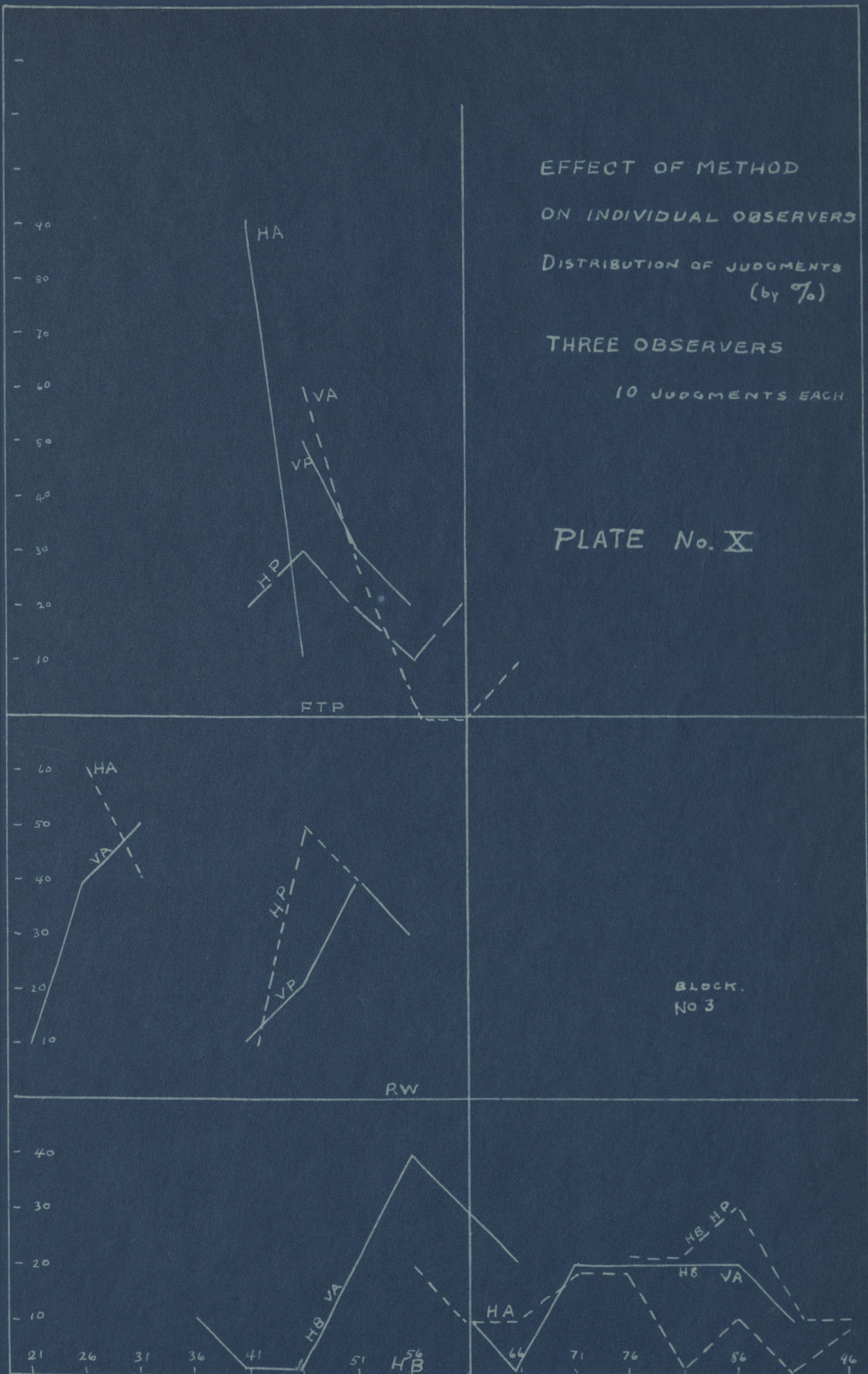
Part Twelve

Relative Consistency of Judgments Within Observers and Between Observers

Individuals are more consistent with themselves in making their judgments than are groups of individuals. In other words the range of distribution of judgments both of height and width and of squaring is due to differences between individuals rather than to scattering of judgments within given individuals.

Plates IX and X demonstrate this fact and show that the consistency holds within individuals from position to position, from method to method, and from block to block.


DISTRIBUTION OF JUDGMENTS BY PER CENT TRAINED OBSERVERS SEPARATELY
VERTICAL PASSIVE METHOD 10 JUDGMENTS EACH OBSERVER
BLOCKS ONE AND THREE
PLATE No IX
No 3
No 1
CW W
MR W
FP W
KS W
RK W
CW H
MR H
FP H
KS H
HB W
RK H
HB H
DP W
EN W
WW W
DP H
WW H
RW W
HB W
EN H
RW H
HB H


EFFECT OF METHOD
ON INDIVIDUAL OBSERVERS
DISTRIBUTION OF JUDGMENTS
(by %)
THREE OBSERVERS
10 JUDGMENTS EACH
PLATE No. X
BLOCK.
No 3
FTP
RW
HB
HA
VA
HP
VP
HB VA
HB HP
90
80
70
60
50
40
30
20
10
21
26
31
36
41
51
56
66
71
76
86
96

Part Thirteen

Difference Between Individuals and Groups in Squaring The tendency toward squaring shows more consistency within individuals than it does between individuals. Like the judgments of size the individuals retained their own consistency under the different conditions although the actual amount of squaring was made greater or less owing to a given condition.

The range of all individuals from the least amount of squaring to the most squaring for all positions and for all blocks was 50.6. The greatest range of any individual in any position was 24.7. The least range was 1.9 for a given position. The least average range for the four methods was 4.7 and the greatest was 16.1. The average of all individuals was 10.0.

Part Fourteen

General Differences Between Trained and Naïve Observers. Visual Judgments Throughout the presentation of the results there have appeared differences between the group of trained observers and the untrained group. The apparent differences between these two groups are difficult to describe in quantitative terms. In the following paragraph will be presented the differences between the two groups as shown by the experimental data. No attempt in this section will be made to interpret the differences.

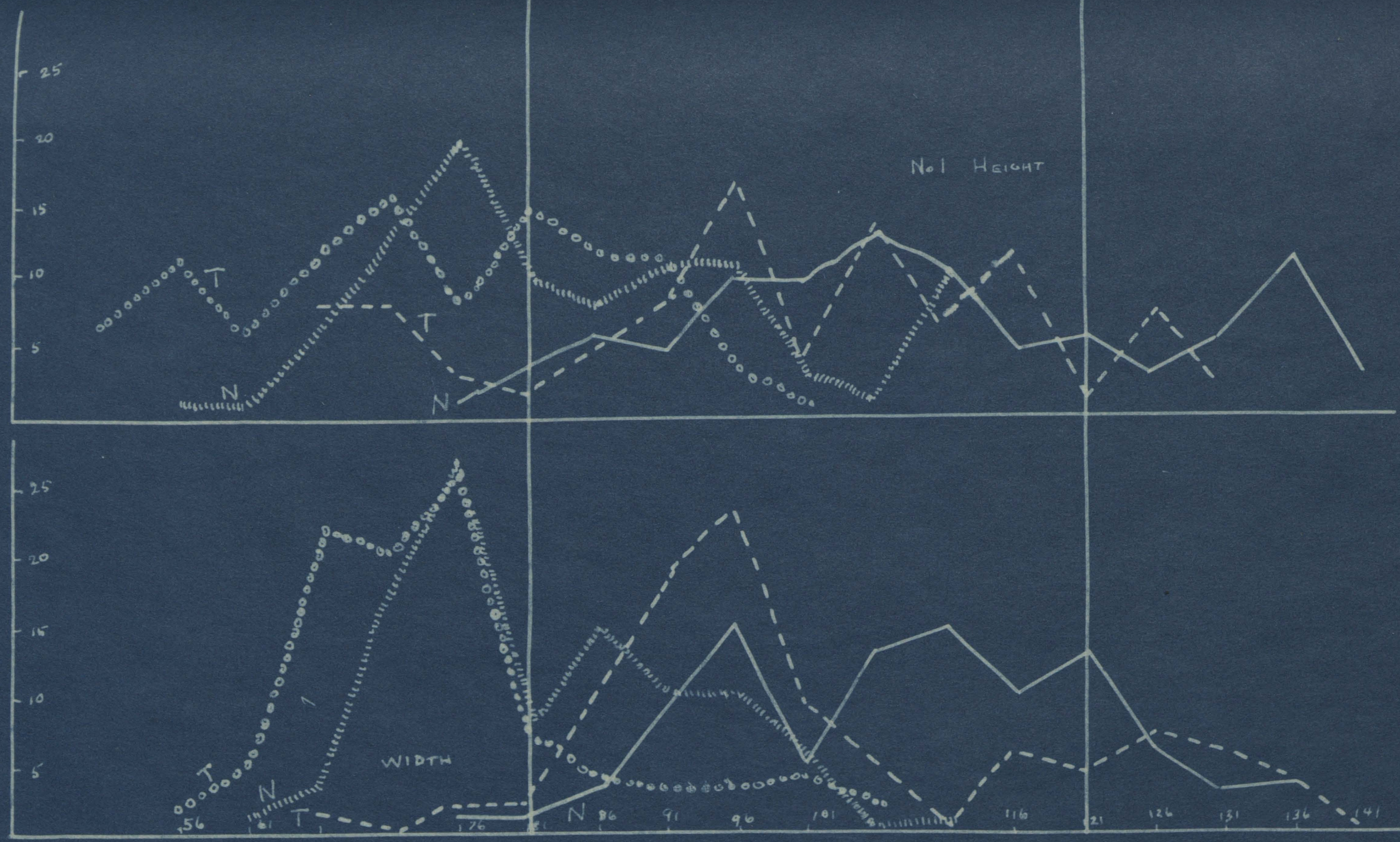
In comparing two visual forms untrained observers underestimate the standard while the trained observers showed the opposite tendency, that of overestimating the standard. These diverging tendencies were consistant for both height and width.

The trained observers tended to square the visual form more than the untrained observers.

In their judgment of tactual standards the untrained observers are more consistant, as shown by higher modes in the curves of distribution. The trained observers give more exaggerated and frequent bimodal distributions.

Part Fifteen

Differential Effect of Position on Trained and Naive Observers Table V shows the effect of position upon the two groups of observers. It will be found that the vertical position favors an overestimation of both height and width by the trained observers, while the horizontal position favors overestimation in the untrained observers. The vertical position favors more underestimation of height and width by the trained group of observers although both groups do a great deal of underestimating. In other words, the trained observers do more underestimating in the horizontal position than do the untrained and the difference is increased in the vertical position.



DISTRIBUTION OF JUDGMENTS NUMBER OF CASES BLOCK ONE HORIZONTAL PASSIVE METHOD

N = NAIVE SUBJECTS 60 JUDGMENTS T = TRAINED SUBJECTS 100 JUDGMENTS

PLATE No XI

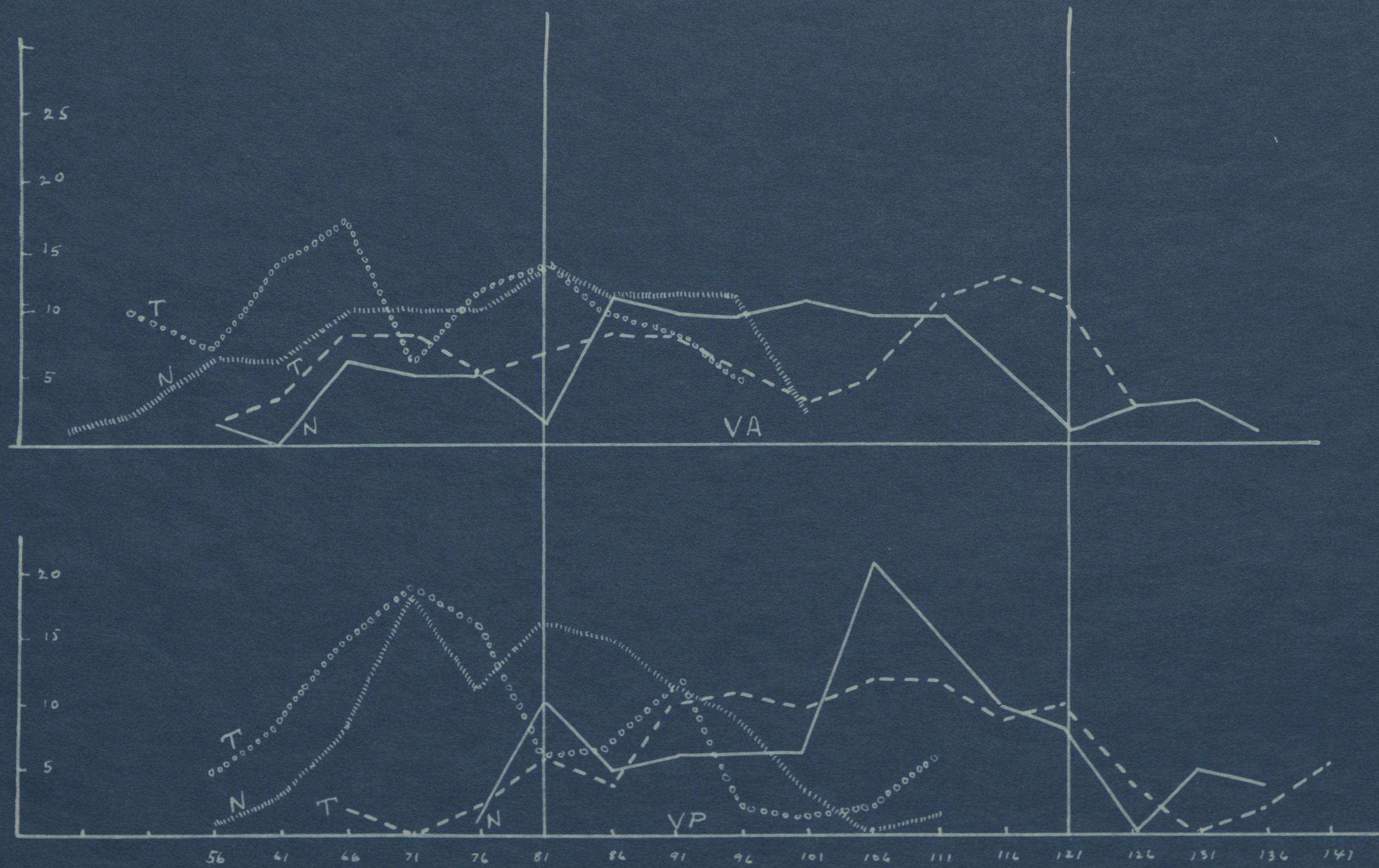
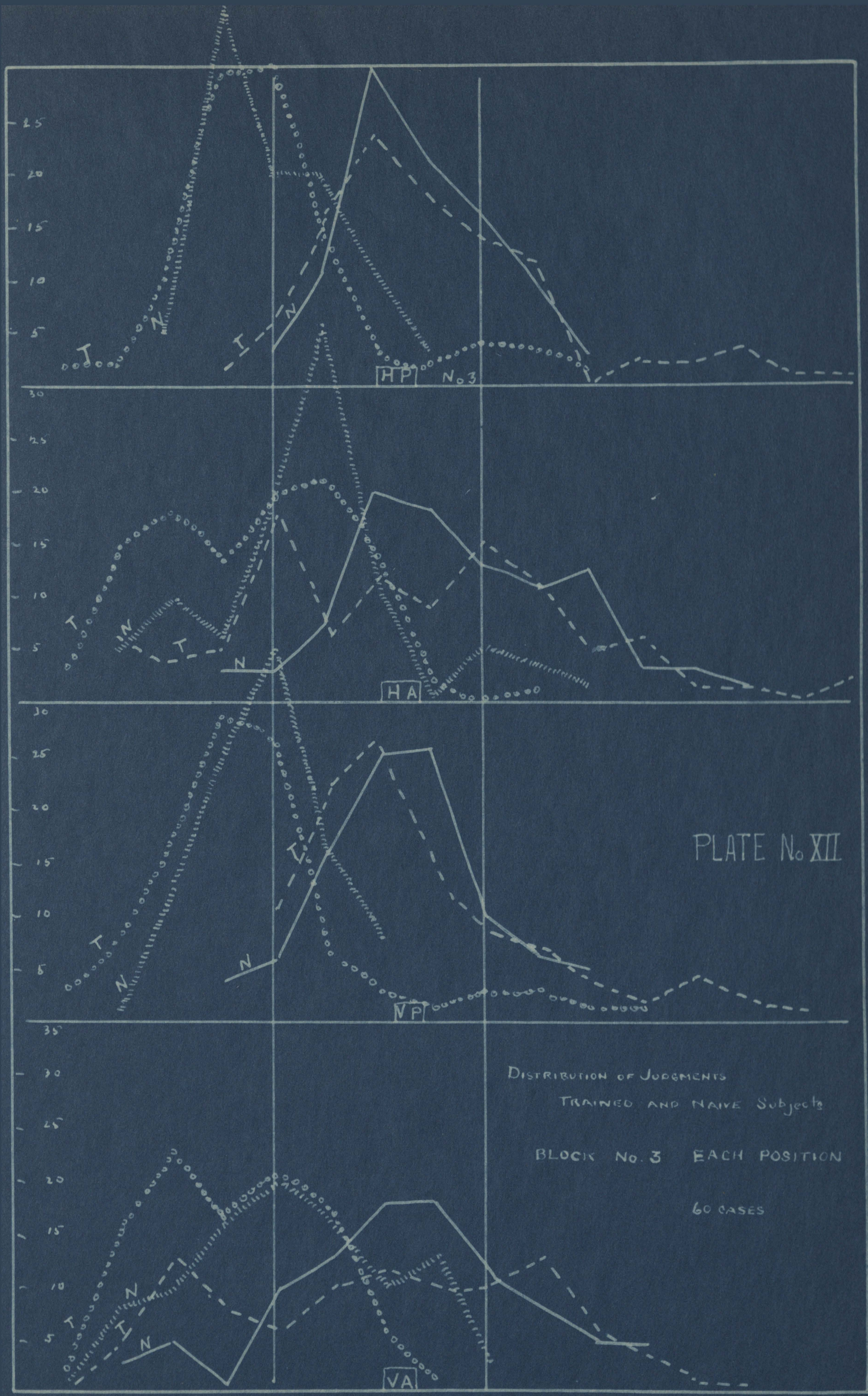


PLATE No. XI
CONTINUED.


HP No 3
HA
NP
VA
PLATE No XII
Distribution of Judgments
Trained and Naive Subjects
Block No. 3 Each Position
60 cases

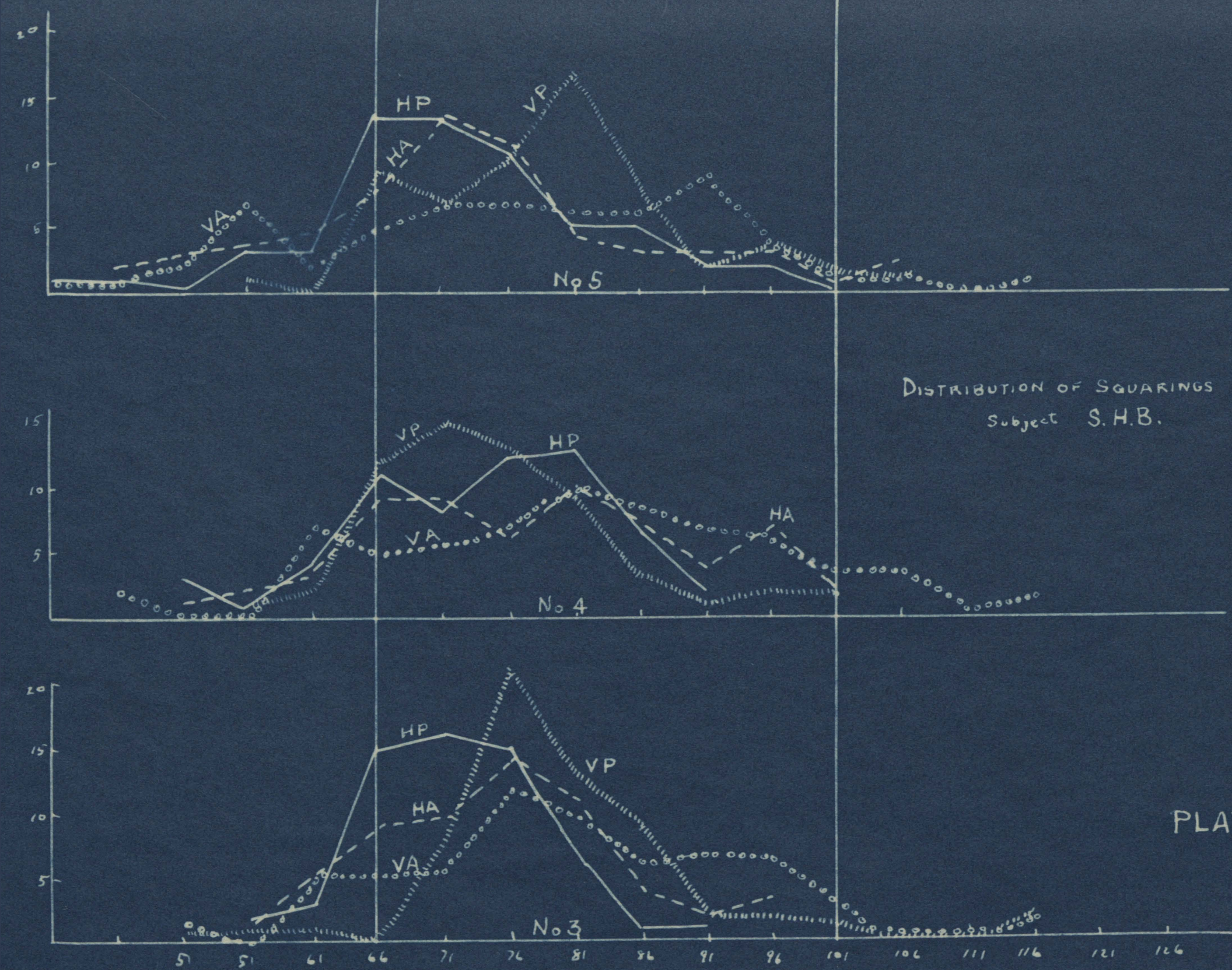
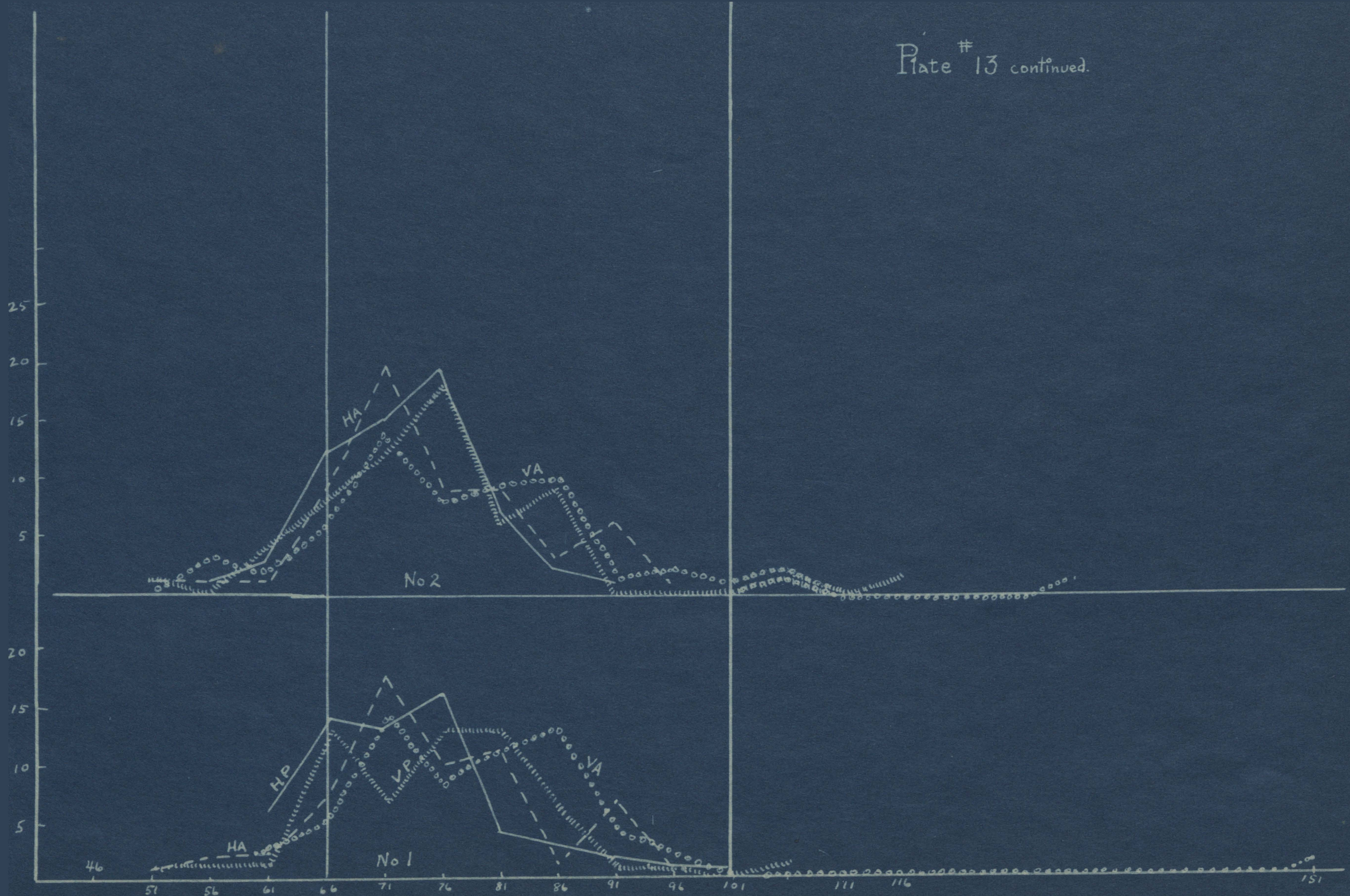


PLATE No XIII

Plate # 13 continued.



The untrained observers make more judgments toward squaring on both the horizontal and vertical positions. In the former position they are in excess of the trained group to the extent of seventy-one judgments and in the latter position to the extent of one hundred and fifty-two judgments.

Part Sixteen

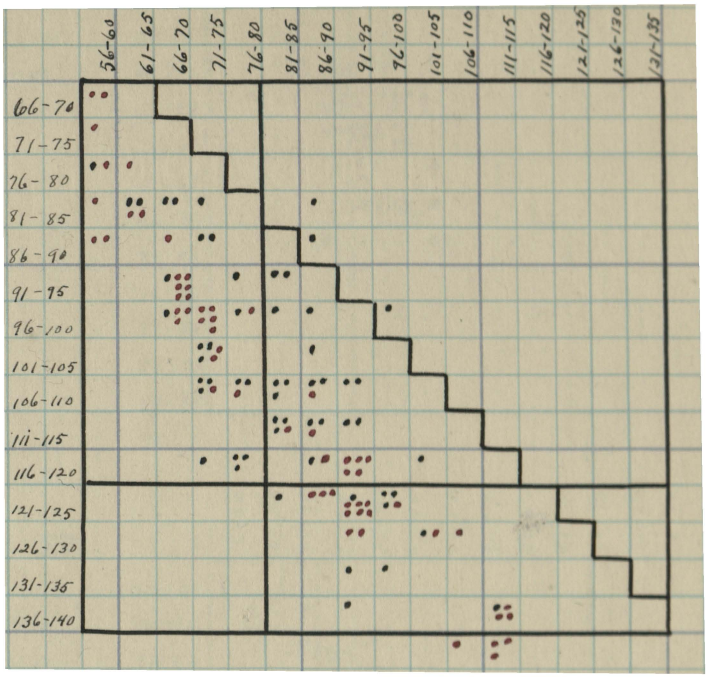
Differential Effect of Method on Trained and Naive Observers The active method of exploration supports approximately twice as much squaring as does the passive method. The untrained group do more squaring in both methods than does the trained group, but the greater excess of squaring occurs under the passive method. This would indicate that the two methods have opposite effects on squaring in the two groups of observers.

Part Seventeen

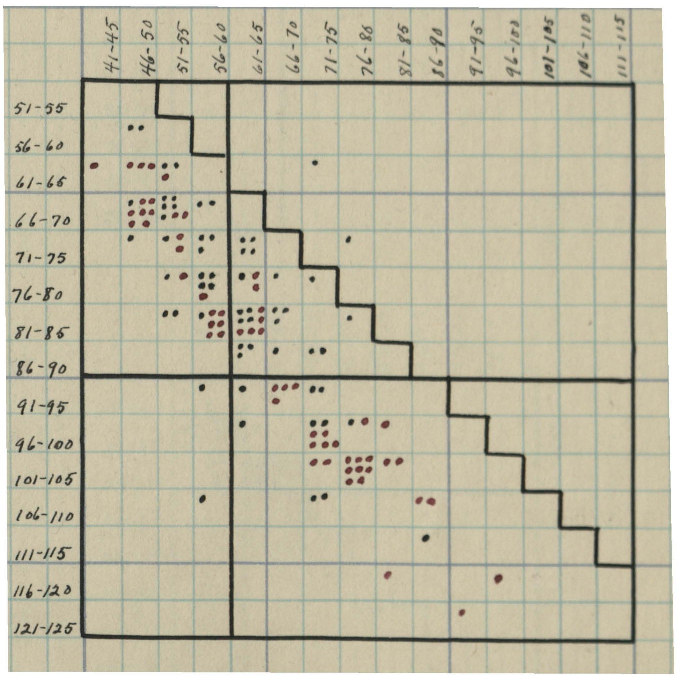
Differential Effect of Size of Block Upon Trained and Naive Observers The series of five blocks as a whole is underestimated much more by the trained subjects than by the untrained. As the blocks become progressively smaller this difference is increased.

Table V shows this difference between the two groups with respect to underestimation of the various blocks. In block one the two groups are about even. In block two the trained overestimate a little more than do the untrained. In block three the two groups are about the same. In block four

I



II



SCATTER OF JUDGMENTS. VERTICAL PASSIVE METHOD

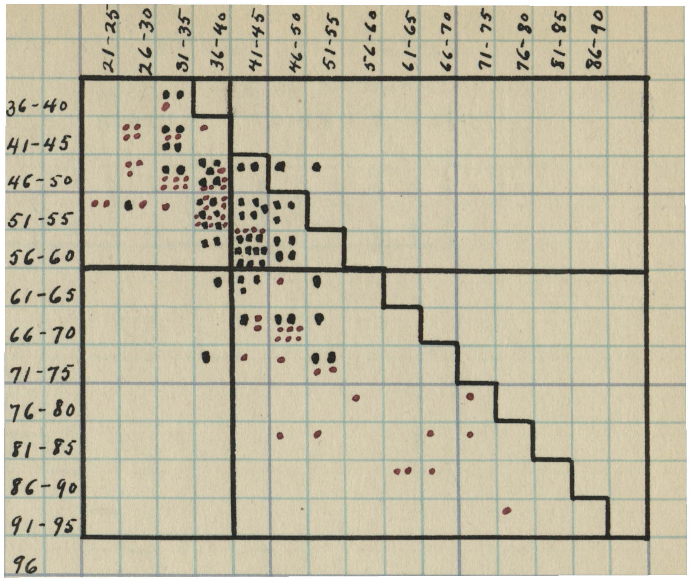
RED = NAIVE SUBJECTS

BLACK = TRAINED SUBJECTS

PLATE XIV

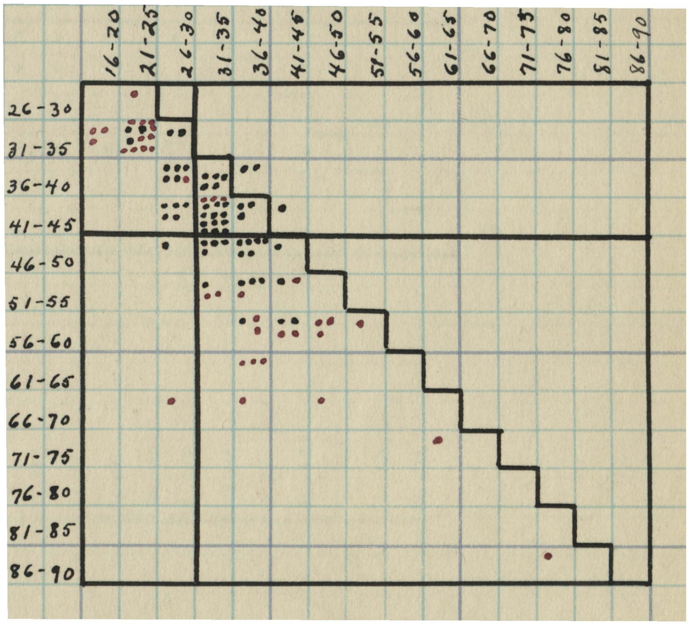
BLOCK III

Vertical Passive



BLOCK IV

Vertical Passive



BLOCK V

Vertical Passive

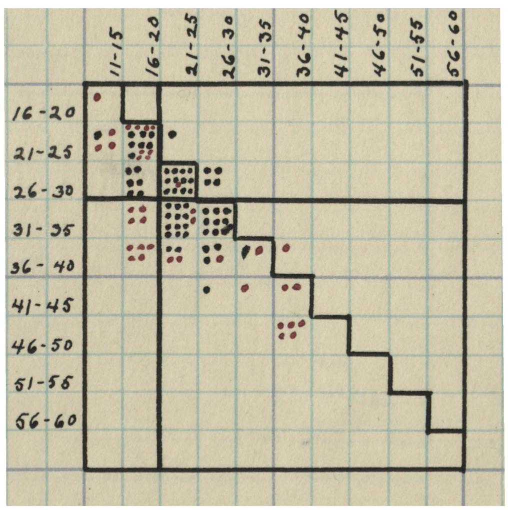


PLATE XIV

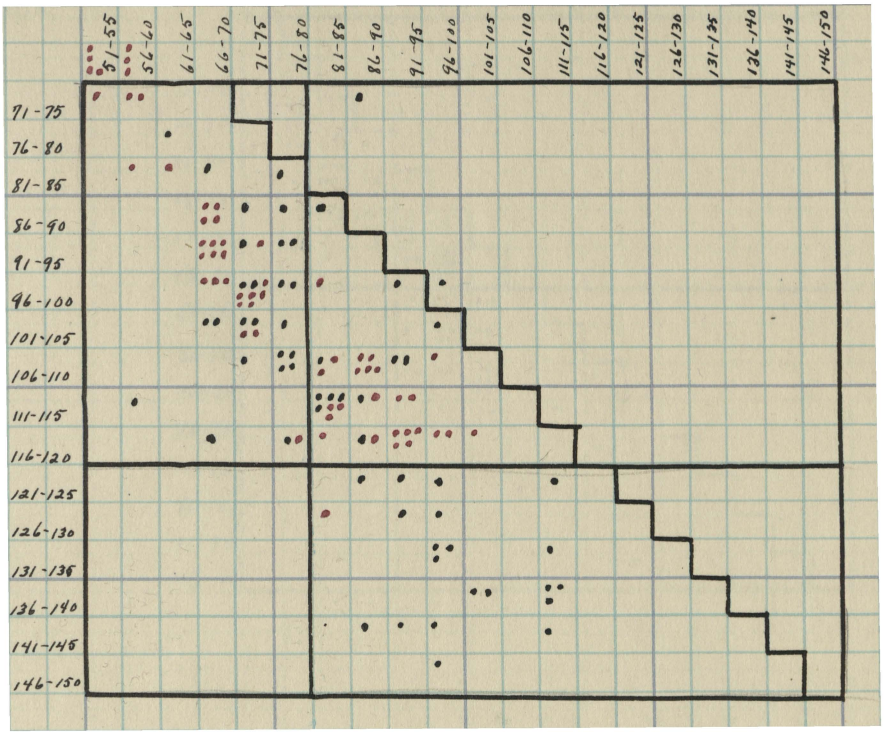
continued

SCATTER OF CASES IN HORIZONTAL ACTIVE JUDGMENTS

RED = NAIVE SUBJECTS
BLACK = TRAINED SUBJECTS

I

BLOCK I



II

BLOCK II

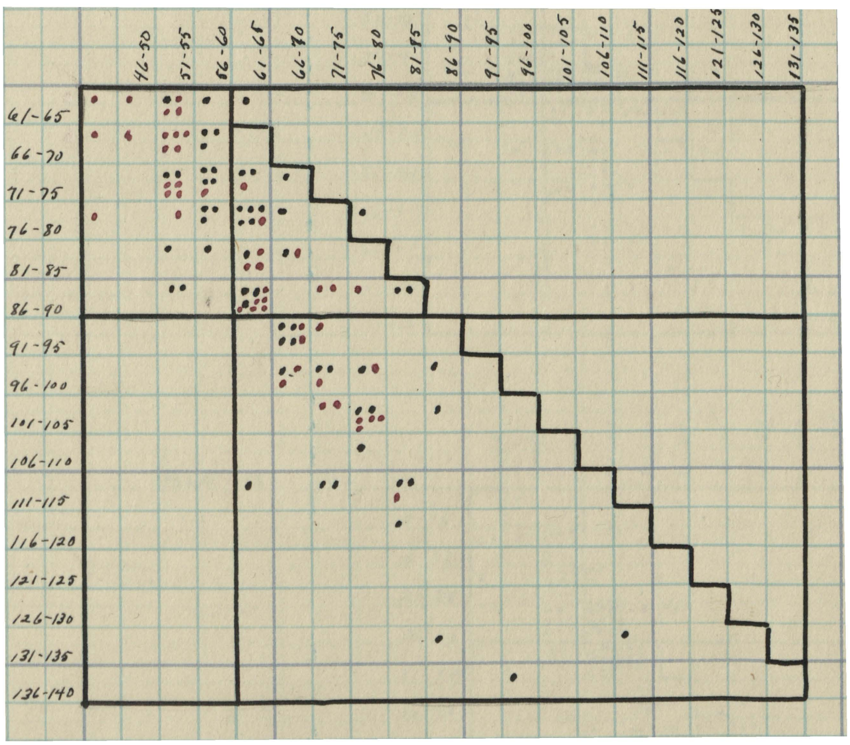
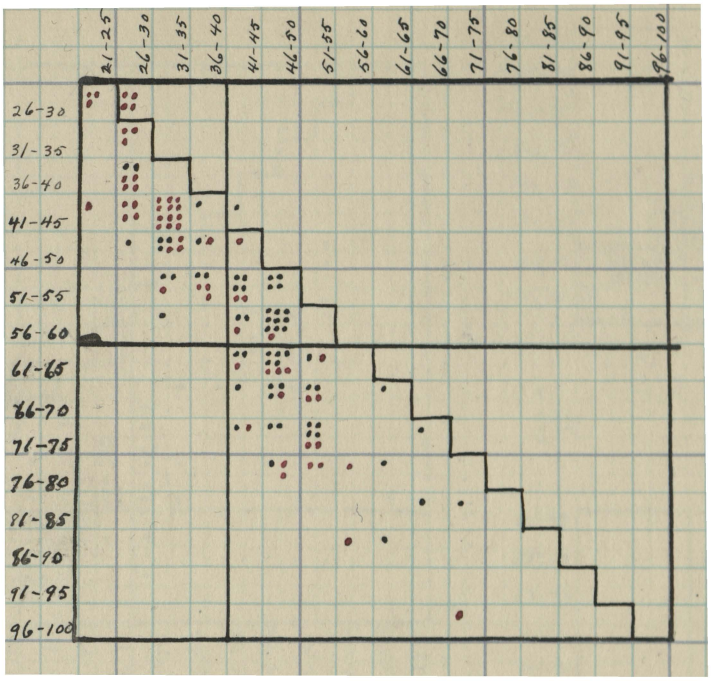
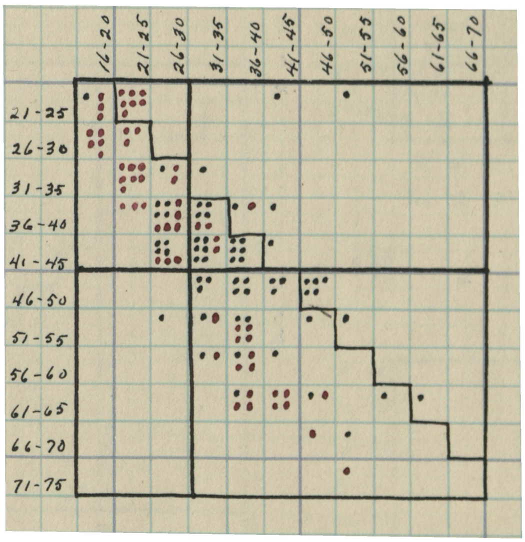


PLATE XV

BLOCK III



BLOCK IV



BLOCK V

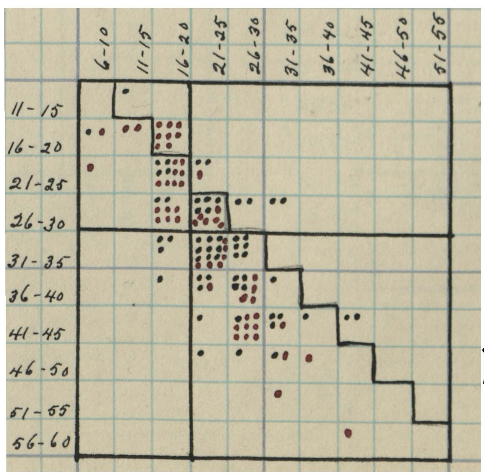
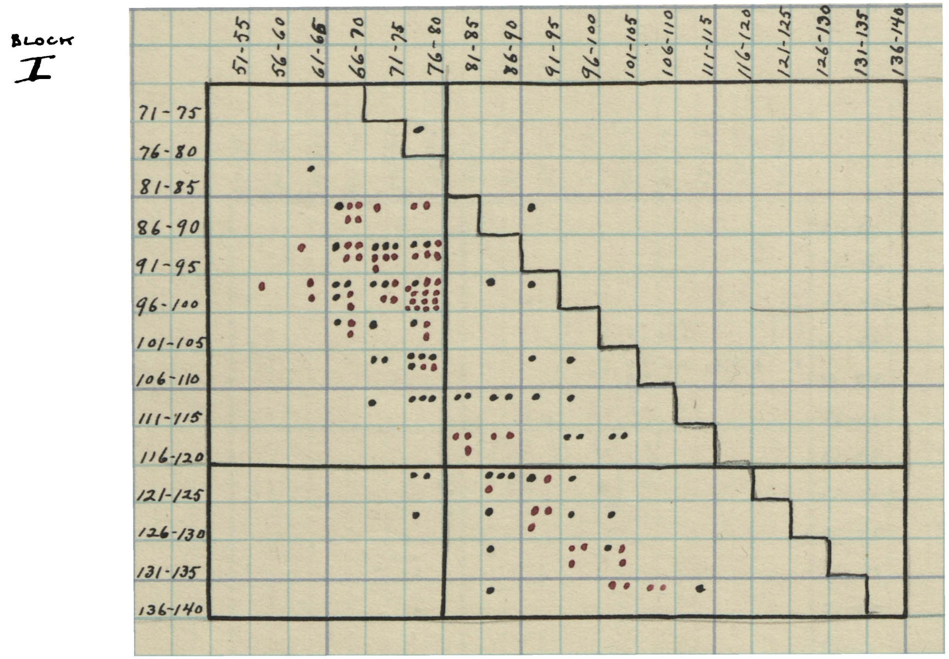


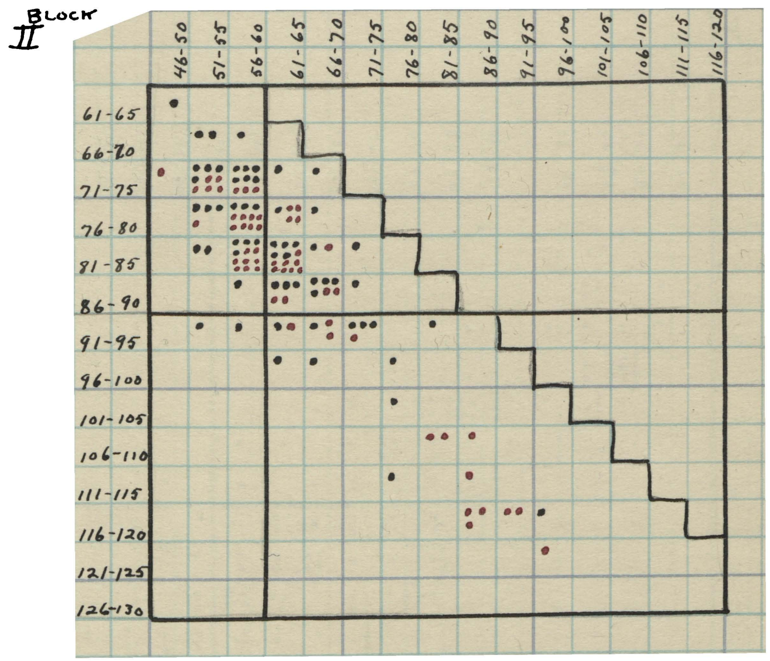
PLATE XV

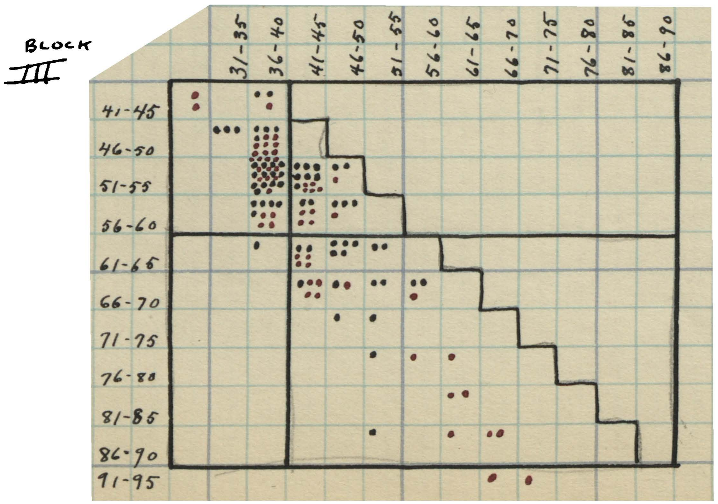
(continued)

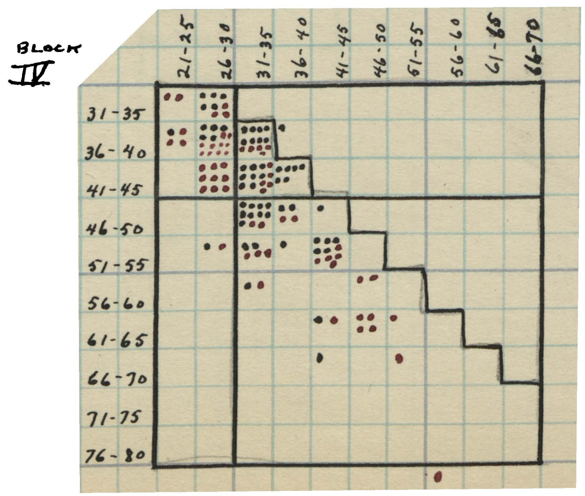
Scatter of Judgments Horizontal Passive Method

RED = NAIVE SUBJECTS
BLACK = TRAINED SUBJECTS









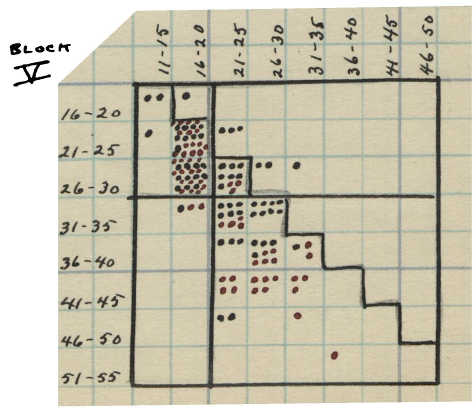
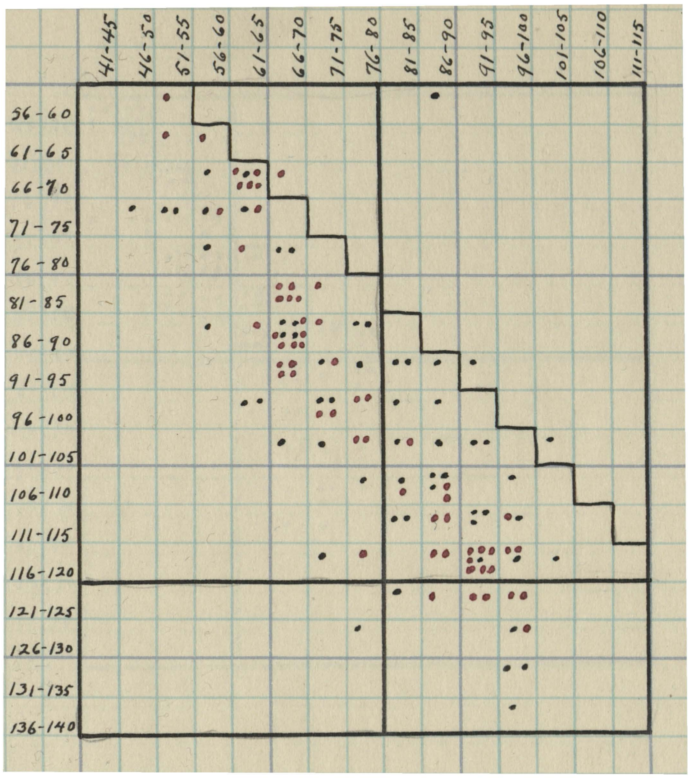
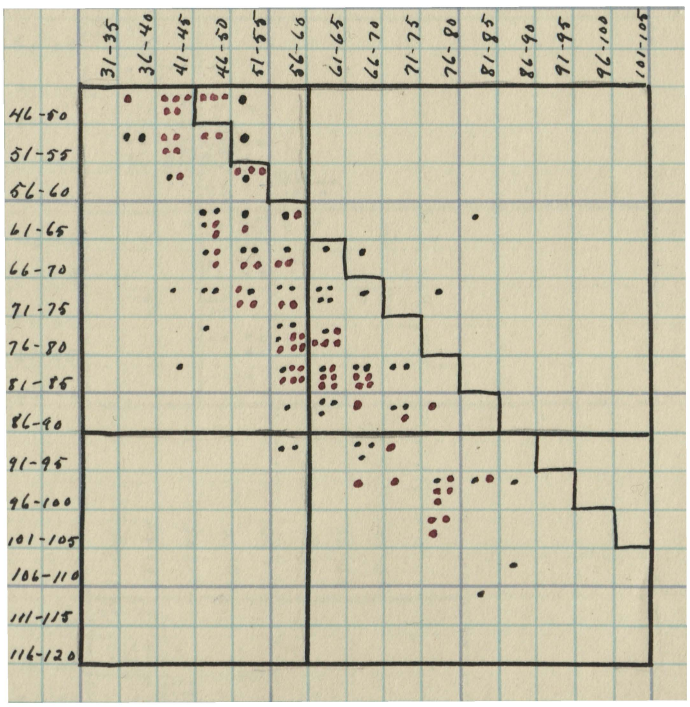


PLATE XVI

Block I



Block II



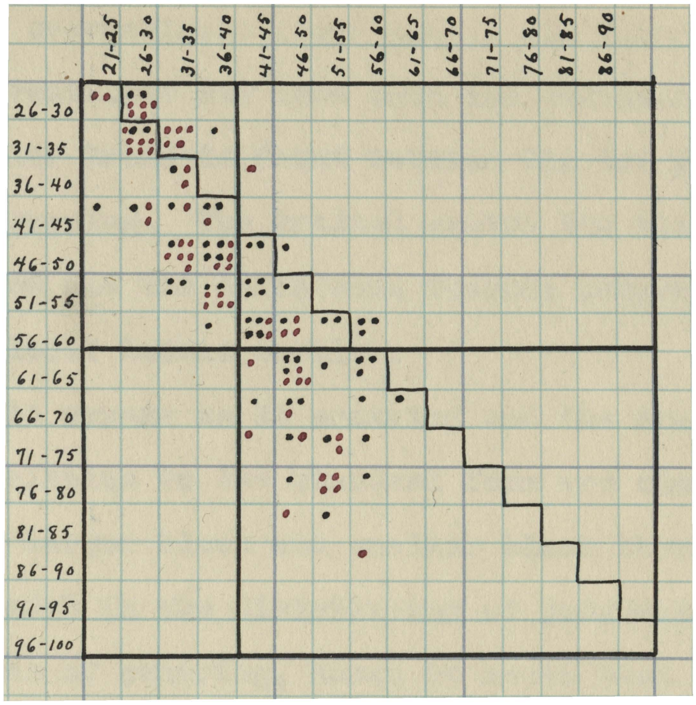
Scatter of Judgments Vertical Active Method

Red = Naïve subjects

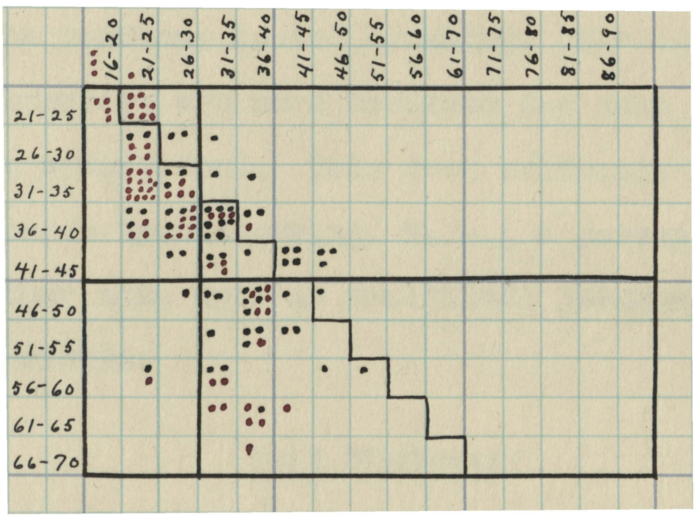
Black = Trained subjects

PLATE XVII

BLOCK III



BLOCK IV



BLOCK V

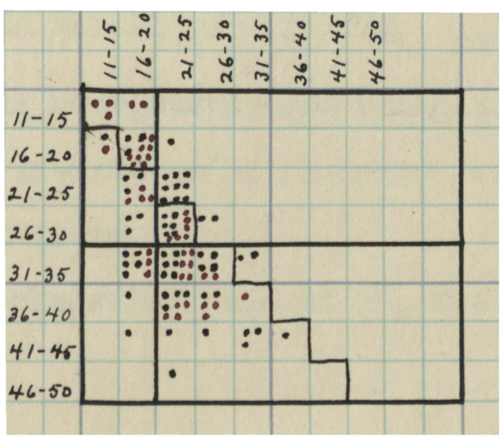


PLATE XVII

continued

the trained overestimate fewer times. In block five the trained overestimate far less than the untrained.

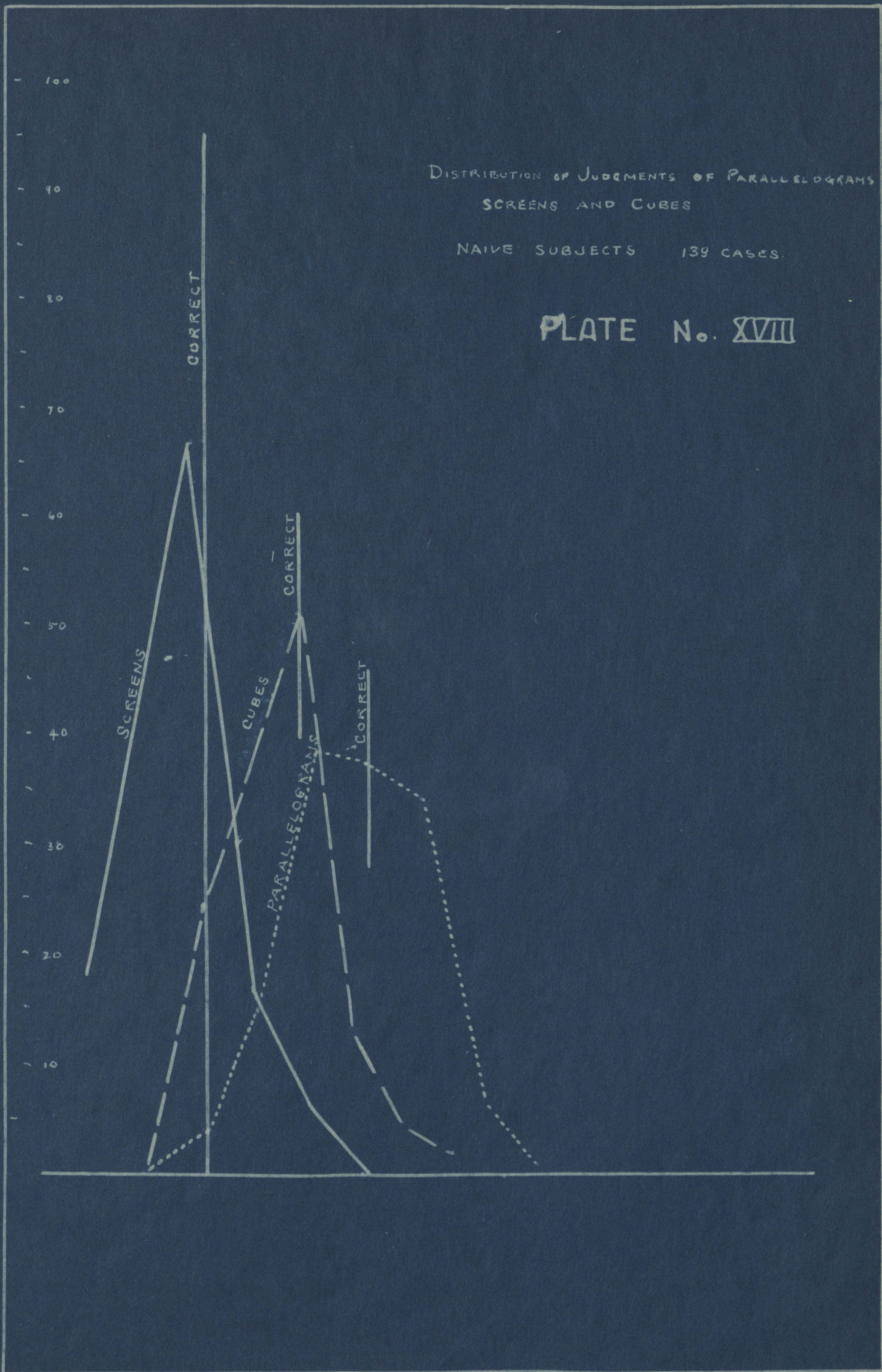
A similar trend is found between the two groups in the extent of squaring. The trained square the blocks less than the untrained and the difference becomes progressively greater as the blocks become smaller.

It would appear as if squaring and the range of distribution in relation to the standard form are closely related. In both the larger block and smaller block there occurs a greater breadth in the distribution of judgments and also a less amount of squaring, hence it would seem that the extremes of size destroy both accuracy in judgment and at the same time the tendency toward symmetry. Throughout, the untrained observers are more accurate and make their visual figures more symmetrical. This fact evidently means that accuracy depends upon squaring, i. e., a perception of proportion, rather than upon an analytical judgment of discrete heights and widths.

Part Eighteen

Results from Naïve Observers on Screen, Cubes and Parallelograms Plate XVIII and Table VIII give the results of the steriognostic recognition and identification from one hundred and thirty-five naïve observers who judged screens, cubes, and parallelograms.

It was characteristic of all the responses of all the



DISTRIBUTION OF JUDGMENTS OF PARALLELOGRAMS
SCREENS AND CUBES
NAIVE SUBJECTS 139 CASES.
PLATE No. XVIII
100
90
80
70
60
50
40
30
20
10
CORRECT
CORRECT
CORRECT
SCREENS
CUBES
PARALLELOGRAMS

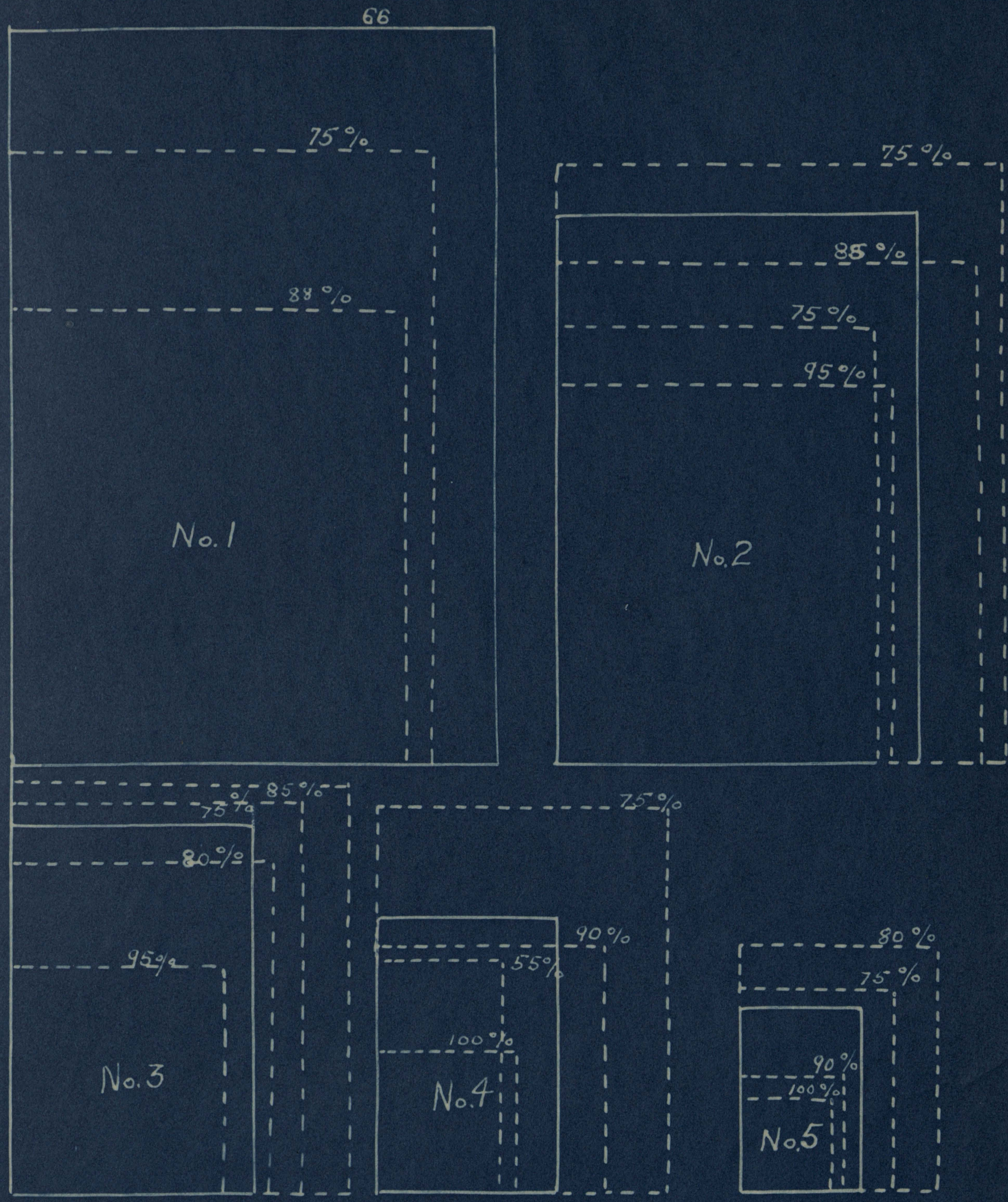


PLATE XIX

Typical Actual Judgments

Showing Extent of Squaring

observers on the visual recognition of tactually perceived objects that they were not at all sure of their recognition and preferred that the choice be taken more as a guess than a judgment. In not a single case was any judgment made with the least suggestion of certainty. There occurred many instances in which the observer would maintain that none of the objects in the visual series was representative of the tactually perceived object.

Due to individual differences in the rapidity of finger movement, judgments of screens varied widely. To the inexperienced a rapid movement in the perception of wire screen gives the perception of a much finer mesh than a more firm and deliberate movement gives.

A. Wire Screens In the distribution of judgments of the wire screens there is seen a tendency to select the next step larger mesh. There occurs twice as many recognitions of larger mesh than smaller mesh. Many subjects reported that their choices between screens 1 and 2 were determined by the fact that screens 1 and 2 were most like the common window screen and that the tactual screen felt much like the tactual memory of window screen.

B. Cubes The recognition of cubes reveals ample evidence that the observers perceived a tactual cube larger than the same cube perceived visually. Although the mode in the distribution of recognitions fall upon the correct sample in fifty-one cases, in sixty-seven cases larger cubes were selected. On only seventeen cases were cubes identified that were too small.

C. Parallelograms It is quite evident from the distribution of visual recognitions of the parallelograms that the form of a figure of varying angles and widths is less accurately perceived than form with a variation simply in magnitude. It was impossible to insure a strict following of instructions in judging the parallelograms for the observers were so bewildered by the form of the diamond shaped figure that they abandoned any criteria of form and would resort to a comparison of lengths of lines and widths of angles. The table of distribution shows that only thirty-seven judgments were correct; fifty-six were identified with samples approaching a squarer form and forty-two with parallelograms which were receding from a square figure.

Part Nineteen

Qualitative Results from Judgments of Blocks Unsolicited comments and remarks uttered by observers while sitting for the experiment:

Naïve Observers

1. "The tactual figure is not straight."

2. "The apparatus isn't large enough to represent the block."

3. "The block has an irregular form."

4. "The angles of the block are not right angles."

5. "The blocks appear to be diamond shaped."

6. "I cannot make the aperture fit the block."

Trained Observers

1. H. B. "They all seem to be the same size with the exception of the small one."

2. H. B. "The bigness is not controlled by the size of the block."

3. H. B. "They all seem like a square."

4. E. N. "The judgment seems wrong but I can't do anything about it."

5. E. N. "The block seemed awfully big but suddenly began to shrink on me."

6. E. N. "The longer I explore it the smaller it becomes."

7. R. W. "This one and the next one seem very much alike."

8. R. W. "When comparing the tactual and visual the tactual shrinks."

9. R. W. "When I close my eyes the tactual lengthens."

10. R. W. "When I open my eyes and look at the visual aperture they swell."

11. R. W. "The block gets smaller as I put my hand on it."

12. C. W. "I noticed that I was making them too large when I looked at the size of my left hand upon the crank. My hand was too small when I remembered the figure I had just made."

13. C. W. "I don't see how I could have possibly made it so big."

These excerpts show definitely the dearth of criteria with which an observer can make a comparison between a tactually perceived object and a visual one. It will be shown later that these criteria depend exclusively upon the fact that the tactual perception is as much visual as it is tactual. In fact, there are no tactual criteria, as such, enabling the observer to make his judgment. Hence the discrepancy between the actual sizes of the two figures, the tactual and the visual.

Summary of Introspections

1. Tactual perceptions of form are distorted through lack of possible criteria of judgment.

2. Tactual perceptions of size lack definiteness for the same reason.

3. Both tactual form and size are recognized by the observers as being unreliable and without criteria.

4. Judgments rationally determined were rendered with more confidence than purely perceptual judgments.

5. Apparent movement takes place in tactual-visual perception.

Part Twenty

Apparent Movement At the close of the sixth or last sitting each of the trained observers was given a test for tactual apparent movement. The procedure for this consisted in presenting block three in the horizontal position with the instructions previously given for the active method. He was told to examine the figure very carefully about the edges and to adjust the diaphragms so that the visual figure matched in size the perception of the block. When this was accomplished he was instructed, further, to fixate the visual figure in the diaphragm carefully and at the same time to place his hand upon the block in the manner of the passive method. After this was done the observer was asked to report how the two sizes of the same figure were reconciled, what the appearance was of the figure in the diaphragm and what the appearance was of the figure under the hand.

Three of the ten observers reported that all changes took place in visual imagery of the hand and of the block under the hand. Two of these three reported that the block under the hand appeared to become larger. One reported that he could <u>feel</u> the block get larger during the change, but this was a visual-tactual "feeling."

Five of the ten subjects were able to perceive an apparent movement upon the figure in the diaphragm. Also at times some of them would report an enlargement of the visualized block under the hand.

Two of the subjects were able to get no transitional changes in the perceptions of size. They were aware that change in size had occurred but were not aware of anything until after it had happened.

Introspections of Apparent Movement.

1. E. N. "I visualized my finger movements as I stretched out my hand to place it over the block."

2. E. N. "The changes are in the tactual figure visualized in the hand."

3. T. P. "A definite visual shrinking took place in the block in my hand. It moved in on all sides at once."

4. R. W. "On one side of the visual figure the movement takes place, both as a shortening and as a lengthening of the line. It occurs at the opposite end from that which is fixated. I can produce it on both the vertical and horizontal lines. I must get an actual equality of vividness between the tactual and visual perceptions of the squares before movement will occur."

5. R. W. "The movement of the hand appears to correlate perfectly with the visual apparent movement. It functions when the visualized perception of the tactual square, or form, flits up to the visual form on the diaphragm. Then the tactual size is perceived in the apparent movement and when the tactual returns the visual form retracts to the visual size."

6. R. W. "The change is very rapid and is not always perceived as movement, but merely as a change that has taken place."

7. W. W. "While I am fixating the diaphragm I can see

the tactual block shrink. It is projected up on the aperture with its sides coinciding with the sides of the aperture. The shrinking takes place upon the aperture."

8. K. S. "When the tactual object is again perceived the visual figure increases in size. It changes on all sides in a visual outward movement."

9. H. B. "When I grasped the block it got bigger. It was a visual swelling of the pressure pattern in my hand."

10. H. B. "With a passive grasp of the block and by shifting my hand pressure lightly from one side to the other I can see one side of the visual figure extend in both directions when I fixate the center of the side."

<u>Summary of Introspective Data</u>

1. Apparent movement may take place upon either the tactual or the visual figure, as an effort is made to correct a discrepancy between the two perceptions of size.

2. Ordinarily, apparent movement involves the shrinking or swelling of the whole figure.

3. With an analytical attitude, however, apparent movement may involve but a single side of the visual figure.

4. Under an analytical attitude, the movement may be perceived in a single side as moving in either direction or in both directions when the side is fixated in the middle.

5. The movement may occur in the form of concrete visual imagery or in highly schematized visual imagery.

6. Under the conditions of our experiment, tactual processes, as such, do not yield apparent movement. The movement is seen, not felt.

Part Twenty-One

<u>Tactual Examination of Fish, Man, and Frog</u> As a part of this investigation a brief study was made of the visual recognition of relatively simple forms that were originally examined tactually. Here the plaster of Paris basrelief casts, X., Y., and Z., described on page 5, were used. Nine of the ten trained observers were employed in this part of the investigation.

The procedure consisted of presenting to the observer for tactual examination the figures X., Y., and Z., in order, in a horizontal position, in successive thirty second periods. The exposures were repeated in fifteen second intervals as many times as it was necessary for the observer to distinguish one figure from another tactually. When the observer was able to designate each figure correctly as X., Y., or Z. when they were presented to him, tactually, the series was considered learned. Upon completion of learning, the figures were presented to the observer visually in a vertical position in haphazard order, and the observer was again asked to designate them by the letters X., Y., Z. He was instructed not to guess.

Out of the group of nine observers eight were able to make correct identification of X., Y., and Z., visually. One subject was able to recognize differentially none of the figures visually as the ones he had examined tactually.

There were marked individual differences in the number of repetitions required for the original learning.

<u>Comments made by Observers during Tactual Learning and upon Visual Presentation</u>

1. H. B. (tactual) "The figure gives me the visual suggestion of the grooved drains in the bottom of a silver platter."

2. H. B. "The knobs are like the buds on a tree."

3. H. B. (visual) "The figures look a sight different from what I felt. Didn't mean anything like this. Z. furnished no suggestion of a frog."

H. B.'s visual identifications were correct; his tactual learning very rapid. Contour of gross form, alone, was the criterion of identification. Perceptual form was completed in visual imagery.

4. K. S. (tactual) "Y. seems like a leaf where it fastens to a tree. The two openings in Z. seem like two pockets, one deeper than the other. They all seem as if they may be enlargements of the capsules of the sense organs of touch. Y. and Z. seem very much alike."

5. K. S. (visual) "The objects are not at all what I thought they were."

K. S.'s identifications were perfect. Tactual learning was very slow. This observer was very inept at tactual investigation. Criterion of visual identification: Spaces between appendages and neck. Perceptual form was completed visually.

6. W. W. (tactual) "The spaces between the parts make them look like points on an arrow."

7. W. W. "The parts are not meaningful but look like nonsense figures pressed out."

8. W. W. (visual) "I had no knowledge as to what they really were."

W. W.'s visual recognitions were perfect. Learning quite slow. Criteria of identification were the spaces between the parts. Perceptual form was carried in visual imagery.

9. E. N. (tactual) "They all have the suggestion of fish about them. They all have openings in the tails.

10. E. N. (visual) "They are quite different from what I thought, especially Y. and Z."

E. N.'s identifications were correct. Learning was rapid. Criterion of identification was the form of the appendages, especially the tail, feet and legs, constructed into visual-tactual wholes.

11. T. P. (tactual) This subject showed remarkable tactual perception by immediately recognizing the different figures, correctly differentiating out 'head,' 'fins,' 'leg,' 'arms,' and 'feet.' "They seem like figures pressed out, as for example in Y., the figure appears like the ginger-bread man."

12. T. P. (visual) "They are much more definite in outline and some different in shape."

T. P.'s identifications were correct. Learning was very rapid with great aptitude for tactual exploration. Criteria of identification were the meaningful figures themselves, imagined with the aid of visual imagery.

13. R. W. (tactual) "The figures are symmetrical and suggest leaves and branches; also geometrical designs. In my visual imagery they are similar in plan but different in complexity. The perception as a whole is entirely visual and I can get nothing without finger movement. X. suggests an anchor while Z. suggests a lyre.

14. R. W. (visual) "I never once suspected they were animals." R. W. identified none correctly. He identified X. as Y. and Y. as Z. Learning was rapid with very rapid tactual exploration. Had no tactual criterion which would serve to identify the figures visually. Visual imagery dominated in the tactual exploration.

15. R. K. (tactual) "Took it for granted that they are nonsense figures and noticed details."

16. R. K. (visual) "I hadn't the slightest notion they were meaningful figures.

R. K.'s identifications were correct. Tactual learning was rather slow. Criteria of identification were the different details and their spatial relation to the larger mass of the figure. Tactual experiences were formed in visual terms.

17. D. P. (tactual) "One end of X. and Y. look like the tail of a fish; and the legs of Z. suggest a frog.

18. D. P. (visual) "Z. was not quite that sort of a frog."

D. P.'s identifications were correct. Tactual learning was slow and carefully minute. Criteria of identification were the visual-tactual meaningful figures themselves with some of the smaller details verified verbally.

19. M. R. (tactual) "They all have corresponding bumps at one end. Some are smaller and none of them have the same position."

20. M. R. (visual) "I did not know what they were, so did just what you said and learned to tell them apart."

M. R.'s identifications were correct. Tactual learning was careful and rather fast. He confined tactual examination mostly to the pectoral appendages. Criteria of identification were the different sizes of the 'fins' and 'front limbs.' The spatial arrangements of these appendages was the final deciding cue in the identification, perceived in visual-tactual wholes.

Summary of Introspective Data

1. All perceptions of tactual size, form, and complexity were formed by means of visual imagery.

2. In the act of visual identification tactual experiences become parts of new visual wholes.

3. All visual-tactual perceptions of form, gained through

tactual methods, prove, upon visual inspection, to be distorted.

4. Well formed tactual-visual figures, formed without the aid of objective vision, take on more complete meaning upon visual inspection.

5. The act of visually identifying a visual-tactual form is a very complicated and facile cognitive process of expanding an incomplete visual-tactual whole into a much more organized, differentiated, and meaningful visual perception. This expansion does not come about by the adding together of discrete visual-tactual parts. It is a sudden, creative process which may involve the use of verbal imagery, but it is based upon poorly organized original perceptions, even upon sketchy visual-tactual perceptions of single parts of the original figure.

VI. Discussion

If the results of this investigation confirm the conclusions of Gelb and Goldstein regarding the importance of the visual processes in all sensory perceptions and the conclusions of Wheeler and Cutsforth regarding the nature of the synaesthetic consciousness it is necessary to reconstitute the concept of consciousness so that it will fit into the hypothesis which such findings seem to delineate. The present trend of experimental work upon the special senses is to attribute ever increasing amounts of perception to central organization. The post-injury consciousness of Gelb and Goldstein's patient and the consciousness of a synaesthetic subject give evidence of a further step in the direction either of cortical organization or of organization in the nervous system as a whole. Synaesthetic processes reveal consciousness as unified and operating under the dominance of one sensory modality. The post-injury patient of Gelb and Goldstein presents a picture of a consciousness in which the organization of the whole has been partially destroyed.

It has been a criticism of configurational psychology that the principle of figure and ground and the phenomenon of closure can be demonstrated only in the field of vision. This criticism, when applied to a unified consciousness which functions as a sensory whole, is invalid, first, because it implies that there would exist no other sensory awareness in which the phenomenon could operate, and second, it implies that the field of vision would be the only one in which the observer could find awareness. That is to say, if our awareness does possess a continuous, organized unity, as it appears to do, this homogenous continuity of consciousness must have its expression in terms of some highly organized pattern of energy.

In order to construct a genetic concept of a sensory consciousness, so organized, it is necessary to begin with the direction of conscious differentiation which takes place in the early infant. Through the influences of prenatal maturation the infant is as he is when he is born with the possibility of considerable muscular movement, but an unknown amount of receptivity to exteroceptive stimulation. His muscular movements are general and the results of total undifferentiated nerve patterns, but they are organized. The sense of sight is slow to function with the result that the kinaesthetic processes have a temporal advantage for several days. However, the comparative progress of a child who has his sight, and the congenital blind child shows very soon that sight is a very early factor in the differentiation of muscular coordination. Movement of the hands and feet become organized more rapidly into differentiated patterns with the result that the seeing child is walking months, if not years, before the child who is deprived of visual organization.

If vision is of such importance in the perception and organization of differentiated muscular movements which are already started when the child is born it is legitimate to suppose that vision is also employed in the organization of all the interoceptive and exteroceptive 'sensations' which the infant experiences. This is precisely what the prevalency of synaesthesia among children would indicate.

The patient of Gelb and Goldstein illustrates the extent to which kinaesthesis and everything relating to bodily awareness is inextricably dependent upon vision. The patient was not only not aware of the position of moved limbs but was not able to cognize the difference between up and down without the aid of cognitive rational processes. In introspective observation, the synaesthetic subject can observe for himself the visual equivalents without which the patient is sensorially helpless, and which the average human being, even most so-called trained observers erroneously ascribe to the perceptions of discrete qualitatively pure sensory processes.

The problem of the interrelations of the senses is one which psychologists seldom understand. How is it possible, when consciousness depends upon a visual unity, to differentiate between modalities, such as touch and hearing? Moreover, how is it possible to determine the particular origin of a visual sensation if vision is the only modality employed in vision? Such a situation would naturally permit of no other differentiating qualities which would, if they were present, identify the source of the visual sensation. Unfortunately, there is no brief, concise answer to these questions for they involve an entirely new concept of the unitary organization of consciousness.

In terms of Titchenerian psychology the visually organized consciousness is all one big stimulus-error, but it is an 'error' which the seeing individual cannot help but make. In other words, it is not an error at all but an inherent aspect of perceptual processes even in the so-called non-visual modalities. An observer perceives a nauseated feeling 'in his stomach' in a visualized body or body that is visually schematized. His experience of nausea includes a visualized pulled-down face, teeth flooded with saliva, and a visual something down inside of a visual self.

We are ready to answer the first question, phenomenologically. Experiences that are supposed to be exclusively organic, kinaesthetic or auditory, are perceived and differentiated within visual wholes. Differences in pattern, not differences in pureness of simple qualities, differentiate one modality from another. In the seeing observer, all modalities involve vision. In answering the second question it is only necessary to reflect that vision, in turn, possesses qualitative differentiation within itself but that here, again, the simplest experience contains more than one quality--a red contains yellow or blue, a green contains yellow or blue, and so on. Yellow and red are as immediately perceptible in orange, as orange is itself, to the analytical observer.

But this is not the whole story. The observer suffering from nausea treats the entire experience, including its visual aspects _as if_ it were subjective. On the other hand the congenital blind person who perceives the whistle of a factory off in the distance perceives it in terms of his kinaesthetic organization which is subjective, but he treats his experience as an objective one, i. e., he behaves as if the experience were objective. The degree to which two different organizations, the visual and the kinaesthetic, can become, respectively, subjective and objective, depends upon the employment of a cognitive, rational 'as if' experience.

In distinguishing, therefore, between sense modalities, the quality is not the sufficient criterion at all; it is essential but the differentiation depends upon the existence of larger experiential wholes and before the differentiation is complete that whole must be as comprehensive a one as is often described by the terms subjective and objective.

The aspects of visual perception which are exclusively objective are brightness, color, form, extent, position, and movement. As yet psychology has been unable to discover anything equivalent to these in subjective, kinaesthetic perceptions for the simple reason that observations of the latter have always been made by seeing individuals whose kinaesthetic experiences are rendered objective, i. e., are given form, extent, position, and movement, through vision.

Once vision develops in the individual the original character of kinaesthetic perceptions, if there are any, as such, is lost in a visual organization. They are transformed into visual-kinaesthetic wholes in which kinaesthesis as such loses all identifying characteristics and becomes a homogenous experience that, in terms of William James, can be designated but neither defined nor described. It becomes a parent process in the sense in which Wheeler and Cutsforth have previously used this term.

Let us now carry the discussion one step farther. It has been argued from a nativistic point of view that the congenital blind possess concepts of form and space similar to those of seeing individuals. The proof for such assertions has come from operative cases of the congenital blind who have had an obstruction to their vision removed through an operation. Conclusions from these cases are utterly unreliable for it is impossible to conceive of a condition in which a retina, prepared to function as soon as the obstacle was removed, was not previously a functioning retina. If a retina is to develop to the point at which it is capable of functioning it must have had previous stimulation of diffuse light which possessed brightness, extent, form and movement, or else these aspects of vision have their beginnings in visual experiences which come about through maturation of an optic system without the aid of external stimulation. This latter possibility is not entirely without the range of comprehension since it is now known that organisms are capable of making organized movements without previous stimulation, indeed, without the so-called sensory half of the nervous system. (Carmichael, Tracy.) There are many arguments which cannot be advanced here, indicating the possibility that the congenital blind do have some degree of vision. These problems will be taken up in a subsequent paper.

In the case of the adventitious blind the evidence for the point of view advanced here is clearcut. With the lapse of time a process takes place which is the reverse of the one described for the growing, seeing infant in whom kinaesthesis becomes objectified through vision. In the adventitious blind, vision becomes 'subjectified' through kinaesthesis, but the vision is never entirely lost, any more than kinaesthesis is entirely lost in the growing seeing child. In the adventitious blind, brightness, color, form and extent, position and movement undergo a phenomenological reorganization toward a consciousness that becomes less differentiated visually, but none the less definite. Brightness becomes fleeting and splotched; colors, fleeting and faded; form becomes less clear-cut, extents are broken up; and movement is less well localized, less true in direction. This progressive process is merely one phase of the well known differences that exist between visual perceptions and visual imagery in the seeing. In the adventitious blind, as these changes go on, they become identified with the physical person, i. e., bodily perceptions with a subjective reference.

In the terms of orthodox psychology this process is erroneously described as the dying out of visual imagery and as a vicarious functioning of tactual and kinaesthetic processes. But this is certainly not the case. Sensory and imaginal processes are just as definitely visual as they ever were, but they lose, through the law of least action, their discreteness of form, movement, extent, color and brightness. It is necessary to distinguish between definiteness of visual process and distinctness of form, color, movement and the like.

As time goes on recognizable brightness and color may disappear altogether. The visual field which is at all times present, is reduced to homogeneity so far as brightness and color are concerned so that the qualitative character of the field is unrecognizable. The field has been reduced, qualitatively, to a 'parent process,' merely, visualness. The adventitious blind are definitely aware of visualness with no discernible brightness or color. Visual perceptions of form and extent, then, still exist but they are 'non-sensory' with respect to the aspects of color and brightness. With respect to brightness and color they are static, as is the case in pure <u>phi</u>.

If a seeing individual loses his sight at a sufficiently early age this progressive dropping out of differentiated visual detail occurs early and leaves the person with so meager a memory of visual processes that he can no longer recognize visualness and hence identifies all experiences by referring to the remaining sense organs of touch and kinaesthesis.

Thus it is that, in terms of our previous discussion of objectivity versus subjectivity, the adventitious blind perceives a diminution in the objectivity of tactual and kinaesthetic experiences, the same diminution of objectivity that would appear to a seeing person when he first sees a frog and then feels of one. The shift from objectivity to subjectivity is merely a change of organization of pattern in which bodily reference takes the place of external reference, without the disappearance of visualness.

Those adventitious blind who have developed synaesthesia exhibit a level of tactual-kinaesthetic-visual organization midway between the seeing individual and the blind who have lost their sight very early in life. In these cases of synaesthesia the concrete visual imagery undergoes disorganization, yet there is an organization of non-visual processes to a high degree of visual definiteness, intensity, color and brightness. All cognitive processes take place in terms of highly objectified visual processes. They represent patterns in which maximum energy in the preservation of a visual system, and least action, have found a convenient equilibrium. Absolute objectivity and relative subjectivity have found the same balance as they did in cases in which all objective imagery faded out to equalize the subjectivity of tactual and kinaesthetic processes.

Still further evidence for our hypothesis is found in the field of pathology. The patient of Gelb and Goldstein employed two different methods of bodily localization. One appeared to be on the order of a 'simple reflex' which ran its course without the aid of any volitional effort. It possessed but a very low degree of conscious organization, if any at all, while in process. The second method was highly voluntary and extremely effortful. The localization would be made by first making general movements all throughout the musculature of the body and from out this mass of kinaesthetic activity more local organizations of muscular activity would differentiate out until the spot was cognized. This was not a one to one process between the kinaesthesis and the rest of the conscious field but through intermediate cognitive, rational processes by means of which he objectified the spot. He was forced to objectify the spot as some congenitally blind would have to do, by an 'as if' mode of behavior.

We all possess these two forms of localization, both the seeing and the congenital blind, but in the case of the seeing the 'reflex' form of localization involves no awareness. It is apparently mediated by a movement made under the control of lower brain centers (automatic associative movements). But the observer can voluntarily become aware afterwards that he has localized the spot through movement. This 'reflex' localization has its phenomenological aspect, we may suppose, in a 'parent process' analogous to that sensory parent process which synaesthetic observers report. Whatever it is, it cannot be described; it is an awareness that can only be designated; it is one of those subjective 'impressions' which the average objective individual never experiences as such. It is experience reduced to homogeneity. It means that no sensory experience has a discrete origin in a particular quality, but that sensory qualities are complex wholes, deriving their different aspects from more than one type of sense organ. Thus it follows that it is no more difficult for a person to perceive sound waves clearly and accurately in terms of visual experience than it was for our observers to perceive the size, shape, and position of the blocks employed in this investigation. Both are perceived in exactly the same way. Our observers perceived the blocks in terms of visual experiences. The observers perceived the blocks just 'as if' they were feeling them and some of them still do in spite of the introspective analysis they made of the perceptions. The writer investigated a case of eidetic imagery in which a college girl possessed a degree of visual organization sufficient to enable her to project a negative after image from a tactually perceived ball which she had never seen, and believed to be red. Another college girl was so visually organized that the sound of a tuning fork would bleach out a field of colored paper to a gray. In these two cases the relative subjectivity has approached very near to the absolute objective relation in visual perception. Still the 'as if' sensory connotation persisted, for the two subjects were just as aware of their specific sensory processes as the average man in the street.

Conclusions

1. Under all our experimental conditions discrepancies occur between the 'tactual' perception of size and the visual perception of the same size.
2. The discrepancy between 'tactual' and visual perceptions of the same form occur in all individuals, with the different forms and sizes of standards and under all methods and positions employed in the investigation.
   A. Within individuals the extent of the discrepancy may amount to a plus or minus 47 percent of the standard.
   B. Within a group the average discrepancy may amount to a plus or minus 12 percent of the standard.
3. The extent of the discrepancy occurring between 'tactual' and visual perceptions of the same size is greater for the trained subjects than for the untrained.

3. A. The difference between the two groups is due to the more analytical attitude of the trained subjects who employed more discrete and isolated criteria in forming their judgments.

4. The discrepancy between the two perceptions of the same size was greater when the active method was employed than with the passive method.

   A. The active method of tactual exploration favors a more analytical perception of form, by emphasizing the discreteness of height and width.

   B. The passive method of exploration favors a tactual perception of the entire form as a whole in which both height and width are included not as discrete aspects but as a proportion.

5. The discrepancy between 'tactual' perceptions of size and visual perceptions of the same size is greater when the 'tactual' perception is made with the object in a vertical position than when it is made in a horizontal position.

   A. Vertical 'tactual' perceptions are made with less manual facility and dexterity. The perception is less homogenous and the criteria for making the judgment are less reliable.

6. Discrepancies between the perception of 'tactual' size and visual perception of the same size are greater when the standards are extremely large or extremely small.

6. A. Objects whose size is convenient for manual exploration lend themselves to more accurate perceptions of 'tactual' size.

7. Although underestimation and overestimation of both height and width do occur, underestimations of both height and width are the usual type of discrepancy.

8. The underestimation of height occurs more often than the underestimation of width.

9. In the act of matching a visual form to a tactual rectangle, a figure more closely approaching a square is usually produced.

10. In the act of matching a visual form to a visual rectangle a figure more closely approaching a square is produced.

    A. The squaring usually takes place in the direction of underestimating the height and either underestimation of width to a less extent or an overestimation of width.

    B. Sometimes the squaring is produced by an overestimation of both height and width in the proper proportion.

11. Similar squaring processes occur in both the visual and 'tactual' perceptions of rectangular form. There is a disposition to perceive the figure squarer than it is.

12. Inaccuracies exist in 'tactual' perceptions of stereognostic objects.

    A. The inaccuracies were found to exist in the 'tactual' perception of wire screening, in the 'tactual' perception of cubes and in parallelograms.

13. The 'tactual' perception of proportion is the most reliable basis upon which to construct a visual equivalent.

    A. Greater inaccuracy occurs when less usable criteria are employed.

14. The 'tactual' perception of <u>size</u> and <u>form</u> is exclusively a visual configuration.

15. No tactual <u>patterns</u> were found in the 'tactual' perceptions of form.

    A. The perceptions of form were carried in visual imagery.

    B. Tactual qualities provide 'texture,' 'body,' and subjective reference but form, extent, position and organization are visual.

16. Apparent movement occurs when the discrepancy between the 'tactual' and visual perceptions is noted. Then the movement occurs in the line of least action as a process of equilibration whereby one of the perceptions is corrected to the other. This does not, however, eliminate the error.

17. Apparent movement, under these conditions, is a

visual adjustment made to two visual extents previously perceived in an erroneous fashion as equal.

18. This apparent movement differs in kind with different observers.

    A. Concrete apparent movement occurs in those individuals who perceive movement in their concrete visual imagery. Schematic apparent movement occurs in those individuals who are able to perceive the movement as divorced both from concrete objects and from the body.

19. Apparent movement in its various forms and varieties is always visual under the conditions of our experiment.

20. The exclusively visual nature of apparent movement confirms the fact that 'tactual' patterns do not, as such, exist.

21. The continuity and uniformity of experience, as revealed in this investigation, necessitate the field-concept of sensations, in which one sensory organization serves for all modalities.

22. Throughout our investigation no evidence could be found which leads to the suspicion that a sensory configuration of homogenous quality (tactual) was organized upon the ground of another and different sensory quality.

23. Visual imagery furnishes continuity between otherwise discrete tactual features of complex 'tactual'

perceptions, such as varying intensities and qualities at different places on the skin.

A. Visual imagery furnishes continuity between tactual figure and a conscious ground. The ground of 'tactual' perception is visual.

24. The tactual experiences of our observers reveal, without exception, the phenomenon of synaesthesia.

25. Within the limits of our investigation, 'tactual' perceptions are always visual-tactual. It is evident that in the genetic development of these perceptions, in seeing individuals, maturation and specialization take place only in visual processes, not in the tactual. That is, the form, localization, extent, movement and qualitative differentiation found in so-called 'tactual' perceptions are fundamentally visual.

A. This fact is consistent with the modern trend in psychology to dispense with a systematic differentiation between visual sensation and visual imagery.

26. In the maturation and specialization processes of the adventitious blind, visual processes still play the same role, except that brightness, hue and noncontactual projection may gradually disappear, although 'tactual' perceptions still depend upon visual extent, form, position, and movement.

27. These facts have a direct bearing upon the problem of subjectivity and objectivity. Visual-tactual perceptions of the seeing may rest upon a visual ground projected beyond the body. Visual-tactual perceptions of the adventitious blind rest upon a visual ground projected upon the body. The former projection yields objectivity, the latter, subjectivity. Visual processes in themselves, then, do not differentiate subjectivity from objectivity.

28. The results of this experiment raise the problem of non-qualitative sensory processes. The adventitious blind perceive tactually in visual-tactual wholes in which all recognizable brightness and hue have gone. With respect to these features the visual experience is homogenous. But visual extent, form, position and movement retain their identity, both in figure and in ground.

It is suggested that seeing observers who report tactual and other non-visual experiences as schematized visually, experience similar visual processes having form, extent, position and movement without hue or brightness. But such observers are not, as a rule, qualified to recognize the details of the schemata as visual.

29. Discrete, pure sensory qualities do not, as such, exist. An alleged pure sensory quality derives its

apparent discreteness from the unitary character and organization of the configuration of which it is a member. This configuration, in the nature of the case, cannot be confined to one sense modality. The perceptual experience, however, is so objectified, and so unitary, that it is regarded as a simple experience by the average observer.

30. The problem of discreteness of sensory quality is bound up with the problem of the self in ways which have not hitherto been recognized. The ground on which tactual and other non-visual experiences are figured, although it is phenomenologically visual, is an aspect of the consciousness of self, or in other words, of that total pattern from which objective experiences must emerge by an individuation process. Were sensory qualities discrete, and not dependent, for their properties, upon this total pattern, there would be no way of identifying the quality either as something qualitatively distinct or as the experience of an observer.

31. The systematic implications of these results for a psychology of the emotions, for a psychology of the self, for the psychology of personality, and for a psychological basis of epistemology, are reserved for a subsequent paper.

Bibliography

Benussi, V. Kinematohaptische Erscheinung. Arch. f. d. ges. Psychol., 1913, 29, 385-388.

Benussi, V. Versuche zur Analyse taktil erwechter Scheinbewegung. Arch. f. d. ges. Psychol., 1917, 36, 84, 104.

Brown, G. G., Perception of depth with disoriented vision. Brit. Jour. Psychol., 1928, 19, 117-146.

Burtt, H. E., Tactual illusions of movement. J. Exper. Psychol., 1917, 2, 371-385.

Carmichael, L., Development of behavior in vertebrates experimentally removed from the influence of external stimulation. Psychol. Rev., 1926, 33, 51-58; 1927, 34, 34-47; 1928, 35, 253-260.

DeGowin, E. L., and Dimmick, F. L., The tactual perception of simple geometrical forms. J. Gen. Psychol., 1928, 1, 114-122.

Förster, N., Die Wechselbeziehung zwischen Gesichts- und Tastsinn bei der Raumwahrnehmung, Psychol. Forsch., 1929, 13, 64-78.

Goldstein, K., and Gelb, A., Ueber den Einfluss des vollständigen Verlustes des optischen Vorstellungsvermögens auf das taktile Erkennen. Zsch. f. Psychol., 1920, 83, 1-94.

Hagen, E. von, in Wagner's Handwörterbuch der Physiol., 1844, II, 714 ff.

Judd, C. H., Ueber Raumwahrnehmungen im Gebiete des Tastsinnes. Phil. Stud., 1896, 12, 425-428.

Parrish, C. S., Localization of cutaneous impressions by arm movement without pressure upon the skin. Amer. Jour. Psychol., 1897, 8, 250 ff.

Pillsbury, W. B., Some questions of the cutaneous sensibility. Amer. Jour. Psychol., 1895, 7, 42 ff.

Rosenbloom, B. L., Configurational perception of tactual stimuli. Amer. Jour. Psychol., 1929, 41, 87-90.

Stratton, G. M., Vision without inversion of the retinal image, *Psychol. Rev.*, 1897, 4, 341-360, 363-481.

Tracy, H. C., The development of motility and behavior reactions in the toadfish (*Opsanus tau*). *Jour. Comp. Neurol.*, 1926, 40, 253-370.

Washburn, M. F., Ueber den Einfluss von Gesichtsassoziationen auf die Raumwahrnehmungen der Haut. *Phil. Stud.*, 1895, 11, 190 ff.

Wheeler, R. H., and Cutsforth, T. D., Synaesthesia, a form of perception. *Psychol. Rev.*, 1922, 29, 212-220.

Wooster, Margaret, Certain factors in the development of a new spatial coordination. *Psychol. Rev.*, *Monog. Supple.*, 1923, 32, 96pp.

Zigler, M. J., and Barrett, R., A further contribution to the tactual perception of form. *Jour. Exper. Psychol.*, 1927, 10, 184-192.

Zigler, M. J., and Northrup, K. M., The tactual perception of form. *Amer. Jour. Psychol.*, 1926, 37, 391-397.

Table I

Ranges of Judgments: Trained Subjects
Ten Judgments for Each Method

Block No. 1

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
			Subject R. K.					
H.P.	87- 96	72- 80	93.0	76.5	77.5	95.6	75.3-90.8	81.0
H.A.	98-119	82- 94	117.0	92.0	97.5	115.0	75.2-84.7	78.4
H.Vol.	103-114	87- 92	112.0	91.0	90.3	114.0	76.3-88.3	80.8
V.P.	110-123	89- 95	120.0	91.0	100.0	114.0	72.3-83.3	77.0
V.A.	119-124	89- 94	120.0	93.0	100.0	116.0	71.7-79.9	77.2
V.Vol.	118-126	91- 97	120.0	93.5	100.0	117.0	73.9-81.4	77.5
			Subject C. W.					
H.P.	107-133	77- 94	119.5	86.5	99.6	108.0	66.2-75.4	71.6
H.A.	106-118	85-102	108.0	92.0	90.0	115.0	78.7-88.9	82.0
H.Vol.	105-127	73- 96	116.0	88.0	98.9	110.0	68.2-77.7	73.0
V.P.	95-108	60- 79	98.5	74.0	82.1	92.5	66.7-77.5	73.6
V.A.	98-122	79-100	110.0	87.0	91.7	109.0	77.6-88.0	80.4
V.Vol.	81-116	59- 80	102.0	105.0	85.0	88.1	65.1-76.3	71.5
			Subject T. P.					
H.P.	95-105	72- 77	99.0	75.5	82.5	94.4	70.5-80.8	76.8
H.A.	91- 99	70- 74	96.0	71.5	80.0	89.4	71.4-78.0	74.4
H.Vol.	93-101	66- 75	98.0	72.5	81.7	90.6	70.9-77.3	74.2
V.P.	87- 97	60- 72	95.5	69.5	79.6	87.0	68.9-75.0	72.6
V.A.	87- 96	65- 73	90.5	68.0	75.4	85.0	73.9-75.8	75.0
V.Vol.	88- 92	66- 71	90.0	69.0	75.0	86.2	75.0-78.9	76.3
			Subject W. W.					
H.P.	70- 99	55- 74	88.5	64.5	72.9	80.6	65.9-90.0	73.6
H.A.	66- 99	53- 76	74.0	58.0	61.7	72.5	74.3-87.8	77.0
H.Vol.	70- 91	53- 72	84.0	63.0	70.0	78.7	68.1-83.3	77.9
V.P.	81-111	65- 78	95.5	71.5	79.6	89.4	70.3-80.2	76.4
V.A.	70- 98	51- 67	75.0	57.5	62.5	71.9	64.6-80.8	71.6
V.Vol.	74-100	60- 75	85.0	64.5	70.8	80.6	72.3-83.8	75.3
			Subject M. R.					
H.P.	79-101	62- 79	93.0	70.0	77.5	87.5	63.9-85.4	72.3
H.A.	97-119	75- 87	109.5	82.0	91.2	103.0	71.2-78.0	75.7
H.Vol.	103-110	71- 81	107.5	76.0	87.5	95.0	68.2-73.7	70.8
V.P.	94-113	65- 84	110.0	80.0	91.7	100.0	69.1-77.8	74.0
V.A.	108-114	81- 87	111.5	84.0	90.3	105.0	73.2-76.8	75.5
V.Vol.	107-114	75- 85	111.0	84.0	90.2	105.0	73.5-76.3	74.7

Table I (Continued)

Block No. 1

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
Subject E. N.								
H.P.	111-129	72- 83	124.0	79.0	103.0	98.7	62.6- 65.1	64.3
H.A.	123-135	78- 91	129.0	86.5	107.0	108.0	63.4- 68.9	66.7
H.Vol.	106-122	71- 82	110.5	74.5	92.5	93.1	62.3- 70.0	67.0
V.P.	108-117	69- 81	115.0	76.0	88.5	95.0	63.9- 69.9	66.2
V.A.	117-130	73- 84	122.0	80.0	102.0	100.0	62.4- 67.2	64.7
V.Vol.	106-118	66- 75	111.5	72.0	96.9	90.0	61.0- 67.0	64.7
Subject K. S.								
H.P.	95-110	66- 75	101.0	70.0	84.2	87.5	65.0- 72.6	69.7
H.A.	88-106	70- 76	99.0	72.5	82.5	90.6	71.0- 79.5	73.5
H.Vol.	92-108	67- 77	101.0	74.0	84.2	92.5	68.5- 77.4	72.8
V.P.	84-106	64- 75	103.0	70.5	85.8	88.1	65.1- 76.2	70.0
V.A.	65- 93	51- 65	76.0	58.5	63.3	73.1	66.2- 86.9	79.0
V.Vol.	93-112	67- 76	103.0	70.0	85.8	87.5	60.9- 72.0	69.0
Subject R. W.								
H.P.	100-106	59- 80	100.0	76.0	83.3	95.0	59.0- 78.4	75.5
H.A.	66- 75	53- 59	69.5	56.0	57.9	70.0	74.6- 83.8	80.7
H.Vol.	101-104	74- 78	101.0	75.0	84.1	93.5	71.8- 76.2	74.2
V.P.	115-127	88- 98	123.0	92.5	103.0	95.0	71.8- 78.0	76.0
V.A.	75- 89	59- 72	84.0	68.0	70.0	85.0	77.4- 84.7	81.4
V.Vol.	101-107	80- 86	105.5	83.5	87.9	104.0	77.4- 83.3	78.9
Subject D. P.								
H.P.	89- 96	65- 72	93.0	68.0	77.5	85.0	70.5- 77.4	73.0
H.A.	84- 95	62- 70	91.0	67.0	75.8	83.6	71.3- 79.1	74.6
H.Vol.	83- 90	60- 66	87.5	63.5	72.9	79.4	70.8- 75.9	72.5
V.P.	60- 98	51- 74	67.5	83.0	56.3	78.7	75.5-102.0	90.7
V.A.	68- 89	51- 66	80.5	60.0	67.2	75.0	67.4- 79.4	75.2
V.Vol.	82-101	67- 73	89.5	68.5	74.8	85.6	71.2- 82.9	77.0
Subject H. B.								
H.P.	128-141	93-108	135.0	103.5	113.0	129.0	72.7- 78.3	75.5
H.A.	84-127	57- 85	113.0	105.0	94.2	101.0	66.1- 76.0	70.0
H.Vol.	116-141	78-100	134.5	96.0	112.0	120.0	67.2- 73.1	70.4
V.P.	112-141	82-112	140.5	111.0	117.0	139.0	73.2- 81.6	79.5
V.A.	88-179	69- 96	109.0	79.0	90.0	96.2	66.4- 78.4	75.3
V.Vol.	128-140	94-111	138.0	104.5	115.0	131.0	72.3- 79.8	77.6

Table I (Continued)

Block No. 2

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Mod. Squaring
				Subject R. K.				
H.P.	77- 83	59-65	80.5	62.0	89.3	103.0	71.1-84.4	76.0
H.A.	83-104	66-79	99.0	75.5	110.0	126.0	73.3-80.5	77.3
H.Vol.	98-100	76-79	98.5	77.5	109.0	129.0	76.8-80.6	78.3
V.P.	102-105	75-79	103.5	77.5	112.0	129.0	77.8-77.4	74.6
V.A.	72-103	54-82	100.0	79.0	111.0	131.0	75.0-81.1	78.1
V.Vol.	95-104	78-80	99.0	79.5	110.0	133.0	76.7-83.2	79.8
				Subject C. W.				
H.P.	71- 95	50-71	85.5	61.5	95.0	102.0	68.3-74.7	71.5
H.A.	55- 87	47-74	72.0	56.0	80.0	93.3	72.5-85.4	78.8
H.Vol.	84- 96	56-75	91.5	68.0	97.8	113.3	65.9-78.9	74.7
V.P.	65- 81	48-63	71.5	54.0	78.3	90.0	69.6-78.5	75.5
V.A.	55- 87	43-76	72.0	57.5	80.0	95.9	75.0-88.4	81.3
V.Vol.	57- 80	41-60	70.0	51.0	77.8	85.0	65.0-81.2	70.2
				Subject T. P.				
H.P.	76- 87	57-69	82.0	64.0	91.1	107.0	73.0-79.3	76.7
H.A.	80- 87	49-66	86.0	62.5	95.6	104.0	61.2-77.8	73.3
H.Vol.	83- 87	61-67	85.0	64.0	94.4	107.0	71.7-76.6	73.0
V.P.	77- 83	52-63	81.0	60.0	90.0	100.0	65.8-76.5	74.1
V.A.	80- 82	59-62	81.0	60.0	90.0	100.0	72.8-76.5	74.1
V.Vol.	80- 82	58-62	80.5	60.0	89.4	100.0	71.6-77.5	74.7
				Subject W. W.				
H.P.	55- 84	40-57	66.5	51.0	73.9	85.0	64.5-82.8	71.0
H.A.	50- 83	43-65	62.0	49.5	69.9	82.5	74.2-92.2	83.5
H.Vol.	61- 80	46-64	69.0	52.0	76.7	86.7	71.2-85.7	76.8
V.P.	72- 84	53-63	77.5	58.0	86.1	96.7	71.6-80.8	75.0
V.A.	62- 93	45-62	72.0	52.0	80.0	86.7	66.7-75.0	71.5
V.Vol.	69- 78	52-61	74.0	55.0	82.2	91.7	71.2-81.3	75.7
				Subject M. R.				
H.P.	63- 78	43-54	68.0	50.0	75.5	83.3	65.2-77.9	71.3
H.A.	73- 98	52-75	83.0	64.0	92.2	107.0	71.2-78.0	75.7
H.Vol.	70- 82	47-58	77.0	52.0	85.5	86.7	65.8-71.6	69.1
V.P.	67- 82	48-60	73.5	51.5	81.7	84.4	66.7-73.2	71.5
V.A.	63- 87	44-59	80.0	57.0	88.9	95.0	66.7-74.7	70.5
V.Vol.	70- 79	49-60	74.5	52.5	83.1	87.5	65.8-76.9	72.3

Table I (Continued)

Block No. 2

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
			Subject E. N.					
H.P.	91-104	59- 69	101.0	66.0	112.0	110.0	64.2-68.6	65.6
H.A.	97-111	61- 73	108.0	70.0	120.0	117.0	62.7-67.9	64.9
H.Vol.	81- 94	55- 64	85.0	58.0	94.4	96.7	65.9-71.6	68.2
V.P.	85-103	58- 68	95.5	65.0	106.0	108.0	64.0-70.3	68.6
V.A.	92-109	61- 70	107.0	67.0	119.0	111.0	59.6-66.7	63.2
V.Vol.	82- 98	54- 62	89.0	57.5	99.0	96.0	59.3-69.5	65.1
			Subject K. S.					
H.P.	74- 90	55- 66	84.5	63.0	93.9	103.0	70.0-81.2	73.9
H.A.	67- 95	55- 70	75.0	59.5	83.3	99.1	73.7-85.3	78.8
H.Vol.	74- 87	57- 67	77.0	60.5	85.6	101.0	73.1-81.1	78.3
V.P.	75- 90	54- 63	82.0	58.0	91.1	96.7	67.8-75.3	71.9
V.A.	51- 74	44- 60	64.5	50.0	71.7	83.3	70.1-88.2	75.9
V.Vol.	77- 98	58- 68	92.5	64.5	102.8	107.0	65.6-75.3	71.5
			Subject R. W.					
H.P.	74- 82	55- 65	81.0	60.0	90.0	100.0	71.2-79.3	74.7
H.A.	44- 50	38- 43	47.0	41.0	52.2	68.3	82.0-91.1	87.1
H.Vol.	74- 83	55- 61	78.5	59.0	87.2	98.8	72.3-78.2	75.5
V.P.	76-101	56- 81	92.5	70.0	103.0	117.0	72.3-80.2	75.0
V.A.	42- 59	38- 51	50.5	44.0	55.9	73.3	80.4-94.0	87.5
V.Vol.	81- 92	62- 70	84.5	65.5	93.9	109.0	73.8-79.5	77.5
			Subject D. P.					
H.P.	71- 78	53- 60	75.5	57.0	83.9	95.0	74.0-80.0	75.8
H.A.	60- 72	40- 55	67.5	51.0	75.0	85.0	58.6-84.6	76.5
H.Vol.	66- 74	50- 55	69.5	52.5	77.2	87.5	67.6-81.8	75.0
V.P.	40- 67	35- 60	51.5	47.5	57.2	79.2	85.4-98.0	89.9
V.A.	63- 67	44- 52	66.5	47.5	73.9	79.2	67.1-76.1	72.0
V.Vol.	72- 81	55- 61	78.5	57.5	87.2	95.9	69.1-77.2	73.9
			Subject H. B.					
H.P.	107-125	81- 98	115.0	88.0	128.0	147.0	74.3-81.0	76.6
H.A.	74-113	53- 82	94.0	68.5	104.0	114.0	70.0-73.4	71.2
H.Vol.	105-123	66- 87	111.0	70.0	123.0	133.0	62.8-76.3	70.0
V.P.	96-121	71- 97	105.0	84.5	117.0	141.0	72.6-84.7	79.0
V.A.	73- 96	55- 71	81.0	62.5	90.0	104.0	72.9-80.5	75.4
V.Vol.	115-132	82-100	124.0	93.0	138.0	155.0	71.3-76.3	73.7

Table I (Continued)

Block No. 3

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
				Subject R. K.				
H.P.	53-68	36-53	65.5	45.5	109.0	114.0	65.1-85.5	71.2
H.A.	63-83	45-55	68.0	50.0	113.0	125.0	62.8-77.3	69.8
H.Vol.	64-80	43-52	74.5	48.0	124.0	120.0	62.3-73.4	65.8
V.P.	68-85	44-55	70.0	46.5	117.0	116.0	58.8-71.4	65.8
V.A.	65-87	45-54	77.5	49.5	129.0	124.0	60.2-69.2	65.8
V.Vol.	62-75	47-55	72.5	51.5	121.0	129.0	66.7-76.4	71.9
				Subject C. W.				
H.P.	52-64	33-45	57.5	38.5	95.9	98.2	63.5-74.1	68.1
H.A.	44-65	32-51	54.5	38.5	90.8	96.5	66.7-79.3	73.3
H.Vol.	52-74	37-48	59.0	41.5	98.8	104.0	67.2-78.4	73.1
V.P.	41-58	28-43	49.0	36.0	81.7	90.0	68.3-79.6	73.5
V.A.	36-66	27-57	46.5	33.5	77.5	83.8	70.8-86.4	75.0
V.Vol.	40-58	27-43	48.0	30.5	80.0	76.2	59.6-74.1	66.3
				Subject T. P.				
H.P.	42-62	32-47	51.0	38.0	85.0	95.0	70.9-79.1	75.8
H.A.	41-46	31-35	43.5	33.0	72.4	82.5	73.3-77.8	74.4
H.Vol.	41-60	30-44	51.5	37.5	85.5	93.8	70.9-76.6	72.7
V.P.	43-56	31-39	48.5	34.0	80.8	85.0	67.4-72.2	70.2
V.A.	47-61	34-49	49.5	35.5	82.5	88.9	70.0-75.5	72.4
V.Vol.	43-49	31-36	46.5	34.0	77.5	85.0	71.3-75.6	72.8
				Subject W. W.				
H.P.	46-60	37-48	53.0	40.5	88.2	101.0	68.4-88.9	78.0
H.A.	40-67	35-49	47.0	38.0	78.3	95.0	69.8-95.0	83.7
H.Vol.	42-59	35-44	54.0	39.0	90.0	65.0	68.6-85.7	77.0
V.P.	45-62	31-43	51.5	39.5	85.8	98.7	67.7-79.6	77.2
V.A.	48-73	33-52	63.5	41.5	106.0	104.0	61.8-74.2	65.4
V.Vol.	52-66	35-47	57.0	39.5	95.0	98.7	64.8-77.2	70.2
				Subject M. R.				
H.P.	38-60	23-42	48.0	33.0	80.0	82.2	56.8-72.5	67.7
H.A.	52-79	33-54	60.5	41.0	101.0	100.0	59.4-75.4	69.4
H.Vol.	50-59	31-39	54.5	35.0	90.1	87.5	61.5-67.3	64.8
V.P.	48-59	33-42	52.5	34.5	87.5	86.2	63.5-71.2	68.1
V.A.	47-71	31-49	58.5	38.5	97.5	96.2	61.1-69.0	65.7
V.Vol.	45-57	29-36	48.5	33.5	80.8	83.8	63.5-70.8	67.4

Table I (Continued)

Block No. 3

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
				Subject E. N.				
H.P.	58- 69	40-46	66.0	44.5	110.0	111.0	63.1- 68.9	67.7
H.A.	61- 74	42-52	68.0	47.0	113.0	117.0	65.7- 72.6	69.6
H.Vol.	50- 61	35-42	56.5	39.5	94.1	98.8	66.7- 73.6	69.8
V.P.	55- 64	38-44	61.5	41.0	102.0	102.0	65.5- 74.5	67.2
V.A.	60- 72	40-46	69.0	43.0	115.0	105.0	59.7- 80.9	65.3
V.Vol.	54- 70	35-42	69.0	38.0	115.0	95.0	62.1- 70.0	65.5
				Subject K. S.				
H.P.	51- 64	40-50	59.0	47.5	98.8	119.0	70.7- 86.2	79.5
H.A.	52- 66	44-52	59.0	48.0	98.8	120.0	75.8- 85.4	81.3
H.Vol.	53- 64	43-52	60.0	48.0	100.0	120.0	79.7- 86.8	82.2
V.P.	48- 61	39-45	55.0	43.0	91.7	107.0	68.3- 84.6	76.7
V.A.	35- 52	28-43	43.5	36.5	72.5	90.1	78.0- 91.7	83.8
V.Vol.	56- 72	41-53	65.5	49.0	109.0	122.0	73.1- 80.7	76.0
				Subject R. W.				
H.P.	45- 55	36-43	50.0	38.5	83.3	96.2	72.7- 80.8	78.2
H.A.	28- 32	25-30	30.0	27.0	50.0	67.5	83.3- 93.7	90.2
H.Vol.	41- 53	35-41	48.5	37.5	80.8	93.7	74.5- 85.4	79.4
V.P.	44- 58	35-45	51.5	39.0	85.9	97.5	71.1- 79.5	76.7
V.A.	25- 33	24-30	29.0	27.0	48.3	67.5	83.9-104.0	96.4
V.Vol.	48- 57	37-42	50.5	38.0	84.2	95.0	71.9- 78.9	75.7
				Subject D. P.				
H.P.	45- 58	34-44	53.5	38.0	89.1	95.0	66.0- 80.0	74.9
H.A.	37- 47	27-32	42.0	29.0	70.0	72.5	61.4- 74.4	70.4
H.Vol.	38- 49	25-36	44.0	31.5	73.3	78.7	60.5- 76.2	69.6
V.P.	27- 40	24-41	34.0	31.0	56.7	75.5	85.3-102.0	92.7
V.A.	43- 52	23-37	46.5	28.0	77.5	70.0	51.0- 71.1	61.8
V.Vol.	55- 64	37-46	57.0	41.0	95.0	102.0	64.9- 75.0	70.5
				Subject H. B.				
H.P.	67- 96	56-74	86.0	64.0	143.0	160.0	73.0- 84.1	77.2
H.A.	58-100	41-68	74.5	53.5	124.0	134.0	67.4- 75.0	70.8
H.Vol.	69- 92	40-66	81.5	60.0	136.0	150.0	57.1- 77.5	71.7
V.P.	61- 92	48-77	81.5	63.5	136.0	159.0	70.3- 85.7	78.0
V.A.	37- 65	35-49	57.5	46.0	95.9	115.0	73.7- 94.6	77.0
V.Vol.	73- 99	54-75	89.0	63.0	149.0	157.0	64.3- 76.8	72.0

Table I (Continued)

Block No. 4

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
				Subject R. K.				
H.P.	50-56	28-43	54.0	36.5	120.0	122.0	54.9- 79.6	70.0
H.A.	53-64	37-47	61.5	39.0	137.0	130.0	61.7- 74.6	66.4
H.Vol.	54-66	35-45	61.0	39.0	136.0	130.0	53.0- 68.3	63.3
V.P.	52-68	30-38	59.5	37.0	132.0	123.0	44.1- 68.5	60.6
V.A.	56-68	33-43	61.0	36.5	136.0	122.0	54.1- 70.5	59.2
V.Vol.	57-60	38-42	59.0	39.0	131.0	130.0	64.4- 70.0	66.4
				Subject C. W.				
H.P.	36-47	24-33	42.5	28.5	94.4	95.0	60.0- 72.1	67.4
H.A.	36-42	24-38	40.0	28.5	88.9	95.0	64.3- 95.0	73.4
H.Vol.	38-53	25-38	46.0	32.5	102.0	108.0	62.8- 73.3	66.0
V.P.	28-37	21-28	34.5	24.0	76.7	80.0	67.6- 77.8	70.7
V.A.	28-48	21-39	35.0	29.0	77.8	96.7	72.7- 85.7	78.7
V.Vol.	32-42	21-29	36.0	24.5	80.0	81.7	61.0- 78.4	66.8
				Subject T. P.				
H.P.	34-49	25-38	41.0	30.5	91.1	103.0	68.9- 83.5	75.7
H.A.	28-37	22-28	33.0	24.5	77.3	81.7	71.4- 79.4	76.4
H.Vol.	31-41	22-30	36.0	26.5	82.2	88.3	69.2- 77.8	73.0
V.P.	34-42	23-31	36.0	26.0	80.0	86.7	66.7- 76.5	70.4
V.A.	33-43	24-32	37.0	26.0	82.2	86.7	66.7- 75.8	71.5
V.Vol.	28-34	19-26	30.5	22.5	67.8	75.0	67.9- 80.0	73.8
				Subject W. W.				
H.P.	37-54	29-39	47.5	35.5	105.0	118.0	68.5- 86.8	76.0
H.A.	32-52	30-42	39.5	32.0	87.8	107.0	72.0-100.0	82.0
H.Vol.	32-44	25-39	39.0	30.5	86.7	102.0	67.4- 95.1	77.6
V.P.	36-54	27-36	41.0	32.0	91.1	107.0	61.1- 82.5	74.7
V.A.	45-62	29-37	54.0	33.5	120.0	112.0	56.9- 71.1	61.8
V.Vol.	40-48	27-39	43.0	32.0	95.6	107.0	66.7- 84.8	72.3
				Subject M. R.				
H.P.	27-38	17-24	33.0	21.5	73.3	71.7	58.8- 67.7	63.4
H.A.	38-56	26-37	47.0	29.0	104.0	96.7	58.8- 68.4	66.4
H.Vol.	36-49	21-26	39.5	24.0	87.7	80.0	44.9- 66.7	59.5
V.P.	34-43	19-27	40.0	22.5	88.9	75.0	48.8- 67.5	59.3
V.A.	38-55	22-35	44.0	29.0	97.8	96.7	55.6- 65.1	59.1
V.Vol.	35-43	24-29	39.0	26.0	86.7	86.7	62.5- 73.7	67.4

Table I (Continued)

Block No. 4

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
				Subject E. N.				
H.P.	49-57	33-38	52.0	36.5	116.0	122.0	63.5- 71.1	67.6
H.A.	47-63	30-38	49.5	34.0	110.0	113.0	58.7- 70.8	68.0
H.Vol.	41-50	29-34	45.5	31.5	100.0	105.0	63.8- 72.0	70.5
V.P.	44-49	28-35	45.5	31.0	100.0	103.0	62.2- 72.7	67.7
V.A.	45-59	26-36	50.5	32.0	112.0	107.0	57.8- 67.9	61.6
V.Vol.	40-54	27-35	48.0	32.0	107.0	107.0	64.3- 72.5	66.7
				Subject K. S.				
H.P.	42-62	32-48	48.5	39.5	108.0	132.0	75.5- 88.0	79.0
H.A.	37-61	29-50	45.5	36.0	100.0	120.0	77.0- 89.6	80.9
H.Vol.	38-54	30-42	42.5	36.0	94.4	120.0	77.8- 87.5	82.6
V.P.	38-56	29-39	43.0	32.5	95.6	108.0	66.1- 86.7	74.1
V.A.	30-43	24-38	38.0	30.0	84.4	100.0	69.0- 96.8	81.6
V.Vol.	37-59	29-43	52.0	36.5	116.0	122.0	66.0- 82.3	76.0
				Subject R. W.				
H.P.	32-40	26-32	37.0	29.5	82.2	98.3	78.4- 83.3	80.3
H.A.	22-24	20-23	23.0	21.0	51.1	70.0	86.9-100.0	91.3
H.Vol.	32-39	25-31	34.5	28.5	76.8	95.0	78.1- 85.3	81.0
V.P.	35-41	25-33	38.5	29.0	85.7	96.7	71.4- 81.1	75.7
V.A.	18-23	18-23	21.5	22.0	70.7	110.0	100.0-100.0	100.0
V.Vol.	30-38	25-31	36.0	27.5	80.0	91.7	75.0- 86.7	79.3
				Subject D. P.				
H.P.	35-45	23-32	40.0	27.5	88.9	91.6	60.5- 81.6	68.0
H.A.	26-38	20-25	30.5	22.5	67.8	75.0	65.8- 80.7	70.0
H.Vol.	30-39	17-27	34.5	24.5	76.7	81.7	56.7- 73.5	69.7
V.P.	21-38	19-35	23.0	21.5	51.1	71.7	86.7- 95.7	90.6
V.A.	32-45	18-29	37.5	20.5	83.3	67.3	47.3- 68.4	59.8
V.Vol.	42-53	27-37	48.0	31.0	107.0	103.0	52.0- 69.8	64.7
				Subject H. B.				
H.P.	60-79	45-59	63.0	47.5	140.0	158.0	73.0- 80.0	75.9
H.A.	44-74	31-51	52.5	38.0	117.0	127.0	62.7- 75.0	69.3
H.Vol.	49-69	36-53	58.5	42.5	130.0	132.0	67.8- 76.8	72.7
V.P.	55-88	41-73	60.0	46.5	133.0	155.0	73.3- 88.3	78.0
V.A.	37-53	31-39	45.0	36.0	100.0	120.0	72.7- 92.5	77.7
V.Vol.	61-83	43-63	68.0	50.0	151.0	167.0	70.3- 76.5	72.2

Table I (Continued)

Block No. 5

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
			Subject R. K.					
H.P.	39-45	21-32	43.0	26.0	143.0	130.0	48.8-71.8	60.4
H.A.	40-52	24-32	44.0	26.0	137.0	130.0	53.3-65.0	60.7
H.Vol.	35-38	20-23	36.0	21.5	120.0	108.0	56.8-67.9	60.3
V.P.	34-40	20-23	36.5	20.0	122.0	100.0	50.0-65.7	54.8
V.A.	33-38	19-22	36.0	20.5	120.0	102.0	51.3-63.6	57.5
V.Vol.	31-37	18-21	33.0	19.0	110.0	95.0	54.5-62.5	57.6
			Subject C. W.					
H.P.	26-30	17-21	28.0	20.0	93.3	100.0	60.0-77.8	67.9
H.A.	30-35	19-24	31.5	21.5	105.0	108.0	63.5-73.3	67.1
H.Vol.	29-41	17-26	35.0	21.0	117.0	105.0	51.4-63.4	60.1
V.P.	23-30	18-21	26.0	18.0	86.7	90.0	65.5-78.3	69.6
V.A.	25-30	18-24	28.0	19.5	93.3	98.5	67.9-82.8	73.0
V.Vol.	23-32	15-24	25.0	16.0	83.3	80.0	62.5-75.0	65.3
			Subject T. P.					
H.P.	22-33	17-24	26.0	19.0	86.7	95.0	70.0-81.8	73.6
H.A.	23-28	18-21	25.5	20.5	85.0	103.0	69.2-87.5	76.8
H.Vol.	22-27	17-20	24.5	18.0	81.7	90.0	69.2-77.3	73.9
V.P.	24-30	17-20	26.0	18.5	86.7	92.5	65.4-76.0	70.2
V.A.	27-32	18-23	28.0	20.0	93.3	100.0	64.3-71.9	70.4
V.Vol.	20-24	13-18	21.0	15.5	70.0	77.8	65.0-76.2	72.7
			Subject W. W.					
H.P.	26-34	22-28	29.5	24.0	98.3	120.0	70.6-87.5	84.9
H.A.	25-45	22-39	29.5	24.5	98.3	122.0	73.3-96.0	86.7
H.Vol.	23-32	19-25	29.5	24.0	98.3	120.0	74.2-92.3	79.0
V.P.	28-35	20-25	30.5	22.0	102.0	110.0	57.1-83.3	73.3
V.A.	35-48	24-35	44.0	28.0	147.0	140.0	59.6-76.1	66.6
V.Vol.	26-35	18-24	30.0	21.5	100.0	108.0	60.0-80.0	69.6
			Subject M. R.					
H.P.	22-27	12-16	23.0	13.0	76.7	65.0	51.8-60.9	57.8
H.A.	30-43	17-28	34.0	19.5	113.0	97.5	44.2-73.3	56.8
H.Vol.	28-33	14-17	32.0	16.0	107.0	80.0	46.9-54.8	50.0
V.P.	26-31	14-15	30.5	14.0	102.0	70.0	45.2-55.6	48.4
V.A.	30-40	14-22	36.0	16.0	120.0	80.0	40.5-57.9	46.2
V.Vol.	28-33	15-17	32.0	15.0	107.0	75.0	45.4-60.7	49.2

Table I (Continued)

Block No. 5

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
				Subject E. N.				
H.P.	39-44	23-26	41.0	25.0	137.0	125.0	56.1- 64.1	60.4
H.A.	35-40	21-23	37.0	23.0	123.0	115.0	55.0- 65.7	59.5
H.Vol.	33-36	19-21	34.0	20.0	113.0	100.0	55.6- 61.8	58.8
V.P.	32-39	19-24	34.0	21.0	113.0	105.0	58.3- 66.7	60.5
V.A.	34-44	21-25	41.0	23.0	137.0	113.0	50.0- 61.8	58.5
V.Vol.	30-36	18-22	33.0	19.5	110.0	97.5	57.1- 64.7	60.6
				Subject K. S.				
H.P.	33-43	22-33	38.5	30.5	128.0	152.0	72.1- 84.9	77.7
H.A.	28-38	22-31	34.5	27.0	115.0	135.0	70.3- 83.3	79.3
H.Vol.	28-36	22-29	29.5	23.5	98.3	115.0	75.0- 85.3	79.0
V.P.	24-36	20-22	28.0	21.0	93.3	105.0	61.1- 84.6	72.4
V.A.	25-34	20-29	27.0	22.5	90.0	112.0	76.7- 96.0	82.1
V.Vol.	26-33	20-25	30.0	22.5	100.0	112.0	71.9- 80.0	75.9
				Subject R. W.				
H.P.	23-25	17-18	24.0	18.0	80.0	90.0	70.8- 75.0	75.0
H.A.	16-18	15-17	16.5	16.0	55.0	80.0	88.9-106.0	94.1
H.Vol.	19-22	16-17	20.5	16.0	68.3	80.0	76.2- 84.2	80.0
V.P.	24-28	16-18	27.0	17.5	90.0	87.5	59.3- 69.2	66.0
V.A.	14-18	14-19	16.5	16.5	55.0	82.5	100.0-101.0	100.0
V.Vol.	21-24	16-18	23.0	17.0	76.7	85.0	70.8- 80.9	73.3
				Subject D. P.				
H.P.	28-33	18-22	30.5	20.0	102.0	100.0	61.3- 69.0	66.2
H.A.	19-29	15-20	24.0	16.0	80.0	80.0	63.0- 79.0	69.6
H.Vol.	22-28	13-20	24.5	16.5	81.7	82.5	56.5- 74.1	67.3
V.P.	16-20	15-20	18.5	17.0	61.7	85.0	88.9- 95.0	94.3
V.A.	24-29	10-14	26.5	13.0	88.3	65.0	41.3- 56.0	47.2
V.Vol.	29-35	17-21	31.5	18.0	105.0	90.0	53.1- 65.6	60.0
				Subject H. B.				
H.P.	36-52	26-39	40.0	31.5	133.0	157.0	72.2- 80.0	75.3
H.A.	37-56	25-41	41.5	28.0	138.0	140.0	66.7- 74.0	69.0
H.Vol.	37-43	25-31	40.0	28.5	133.0	142.0	67.4- 74.4	69.5
V.P.	36-50	31-40	44.0	38.0	147.0	190.0	77.5- 90.0	81.0
V.A.	31-39	22-33	34.5	26.0	115.0	130.0	69.2- 89.2	72.9
V.Vol.	44-57	34-41	50.0	37.0	167.0	185.0	70.8- 79.5	74.0

Table II

Ranges of Judgments: 120 Naïve Subjects
Two Judgments for Each Method

Method	Height	Width	Median H	Median W	Prop. Med. to Standard H	Prop. Med. to Standard W	Range of Squaring	Med. Squaring
			Block No. 1					
H. P.	79-140	62-115	112.5	80.5	95.0	101.0	61-102	74
H. A.	77-141	59-115	110.5	83.0	93.0	103.0	52- 98	75
V. P.	80-137	59-114	108.0	83.5	90.0	103.0	53-107	77
V. A.	60-138	49-105	100.0	82.0	83.0	102.0	59-148	80
			Block No. 2					
H. P.	64-119	49- 99	84.0	61.5	93.0	101.0	60- 91	76
H. A.	61-136	52-118	86.0	65.0	95.0	108.0	52- 98	77
V. P.	56-112	47- 89	80.0	62.0	88.0	103.0	55-116	77
V. A.	50-111	38- 93	75.5	60.5	84.0	101.0	55-131	78
			Block No. 3					
H. P.	45- 86	32- 57	57.0	42.0	95.0	105.0	60- 94	74
H. A.	36- 87	28- 72	59.5	47.0	99.0	117.0	60- 97	80
V. P.	40- 74	26- 55	55.0	42.0	91.0	105.0	49-119	74
V. A.	28- 81	23- 65	55.5	44.5	93.0	112.0	53-125	81
			Block No. 4					
H. P.	34- 67	24- 44	43.0	33.0	95.0	110.0	51- 92	81
H. A.	29- 73	20- 65	45.5	36.0	104.0	120.0	53-105	74
V. P.	31- 57	21- 43	43.0	33.0	95.0	110.0	60-103	76
V. A.	26- 62	23- 52	43.0	35.0	95.0	116.0	49-116	81
			Block No. 5					
H. P.	18- 48	14- 32	29.5	22.5	100.0	115.0	45-118	69
H. A.	15- 49	10- 44	33.0	24.0	110.0	120.0	47-110	74
V. P.	21- 43	13- 31	30.0	22.0	100.0	110.0	54-104	77
V. A.	16- 45	15- 36	31.0	23.0	103.0	115.0	47-118	78

Table III

Distribution of Judgments: Naive Subjects
All Methods and Blocks

	Block No. 1								Block No. 2								Block No. 3								Block No. 4								Block No. 5							
	H.P.		H.A.		V.P.		V.A.		H.P.		H.A.		V.P.		V.A.		H.P.		H.A.		V.P.		V.A.		H.P.		H.A.		V.P.		V.A.		H.P.		H.A.		V.P.		V.A.	
	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W
6- 10																																				1				
11- 15																																		3	1	1		1		1
16- 20																												1					3	22	1	10		13	5	16
21- 25																								1		2		0		3		4	13	21	5	23	9	27	12	29
26- 30																				3		1	2	5		13	1	10		13	5	19	20	12	13	14	22	23	12	8
31- 35																		3		6		8	3	6	5	27	2	17	5	24	5	14	14	2	19	8	22	1	18	5
36- 40																2		24	2	4	2	15	1	10	14	10	10	15	12	15	16	14	8		10	1	6		6	1
41- 45																3	2	12	2	12	4	21	6	12	15	8	17	7	24	5	11	8	0		8	2	1		7	
46- 50								1		1				4		7	7	12	5	22	10	10	8	10	14		14	6	12		10	4	2		3					
51- 55								2		12		5		11	4	7	18	7	12	7	15	5	11	6	9		7	2	5		6	2								
56- 60				1		1	1	4		16		14	2	12	2	11	13	2	11	0	16		11	8	1		4	1	2		6									
61- 65		1		1		2	0	4		12	3	12	3	13	6	10	10		8	3	6		7	2	1		4	1			1									
66- 70		2		4		5	4	6	4	9	3	9	7	5	6	7	6		7	2	4		5		1		0													
71- 75		11		8		11	3	6	12	5	9	5	10	10	12	4	2		8	1	3		3				1													
76- 80	1	16	1	12	1	7	3	6	18	3	10	4	9	3	5	2	1		2				3																	
81- 85	1	5	2	6	6	10	1	8	13	1	4	5	10	0	7	4	0		2																					
86- 90	2	9	4	5	3	9	7	7	9	0	7	2	8	1	7	2	1		1																					
91- 95	5	6	3	7	4	7	6	7	8	0	4	2	4		6	1																								
96-100	9	6	6	7	4	5	6	7	3	1	6	0	3		3																									
101-105	3	3	6	2	4	2	7	2	1		4	1	0		0																									
106-110	8	0	8	1	13	0	6		0		2	0	3		1																									
111-115	9	1	7	6	9	1	6		1		4	0	1		1																									
116-120	6		3		6		4		1		1	1																												
121-125	8		4		5		1				0																													
126-130	4		2		0		2				0																													
131-135	2		4		3		2				2																													
136-140	2		8		2		1				1																													
141-145			2																																					

Table IV

Distribution of Squaring
All Methods and Blocks

	Block No. 1				Block No. 2				Block No. 3				Block No. 4				Block No. 5			
	HP	HA	VP	VA	HP	HA	VP	VA	HP	HA	VP	VA	HP	HA	VP	VA	HP	HA	VP	VA
									Trained Subjects											
41															1				4	
46													1		1		2		5	
51											3		1		2	2	2	1	7	3
56	1					1					3	1	5		6	10	5	6	6	6
61	1			2	1	2	1		3	3	7	9	6	6	8	5	11	11	9	8
66	8		8	2	7	1	5	5	14	13	15	10	10	12	17	10	15	7	18	10
71	23	18	29	11	28	15	38	19	16	17	19	19	12	10	16	11	12	10	8	8
76	21	24	21	27	22	22	16	16	20	11	13	1	17	15	7	2	5	5	3	5
81	2	14	2	9	2	10		3	1	5		3	7	1	2	0	6	3	1	0
86	3	4		4		7		12		6		4	1	6		5	2	7		3
91	1			3		2		2		5		4		8		7		5		7
96				1				3				6		2		8		2		8
101				1								3						0		2
106																		3		
									Naïve Subjects											
41																	1			1
46											1					2	1	2		1
51		1	1			1	1	1			1	1		1		0	0	3	1	2
56		2	2	1	1	1	0	3	2	2	1	0	3	2	1	0	3	3	0	7
61	6	2	2	2	3	1	4	2	3	5	0	5	1	3	2	7	3	4	9	2
66	14	7	13	5	12	9	8	6	15	9	8	5	4	9	12	5	13	8	7	5
71	13	18	7	14	15	20	12	14	16	10	21	6	11	9	15	6	13	13	10	7
76	16	10	13	8	19	9	18	8	15	14	13	12	8	6	13	7	11	11	17	7
81	4	11	13	11	7	9	6	9	7	11	9	10	12	10	9	10	5	4	8	6
86	3	1	6	12	2	3	9	10	1	4	2	6	13	7	3	3	5	3	2	6
91	2	7	1	4	1	6	0	1	1	2	2	7	6	4	1	7	2	3	3	9
96	1	1	1	2		1	0	2		3	1	6	2	7	2	6	2	3	2	3
101	1		0	0			0	1			0	1		2	2	3	0	1	1	1
106			1	0			1	2			0	0				3	0	2		1
111				0			0	0			1	0				0	0			0
116				0			1	0				0				1	1			2
121				0				0				1								
126				0				0												
131				0				1												
136				0																
141				0																
146				1																

Table V
Overestimations and Underestimations
Number of Cases out of Sixty

	Block 1		Block 2		Block 3		Block 4		Block 5	
	Tr.	Naïve	Tr.	Naïve	Tr.	Naïve	Tr.	Naïve	Tr.	Naïve
	Overestimations of Height and Width									
H. P.	14	12	14	12	22	19	23	23	24	22
H. A.	1	20	14	23	19	28	19	27	26	35
V. P.	21	10	28	10	21	10	19	19	14	29
V. A.	6	5	11	9	18	19	16	20	16	25
Total H.	15	32	28	35	41	47	42	50	50	57
Total V.	27	15	39	19	39	29	35	39	30	54
Total P.	35	22	42	22	43	29	42	42	38	51
Total A.	7	25	25	32	37	45	35	47	39	60
Total All	42	47	67	54	80	76	77	89	80	111
	Underestimations of Height and Width									
H. P.	42	27	28	27	27	26	27	12	20	24
H. A.	35	25	29	18	36	13	37	10	26	8
V. P.	30	26	25	25	37	22	37	15	38	14
V. A.	36	28	44	29	41	22	48	15	37	10
Total H.	79	52	57	45	63	39	64	22	56	32
Total V.	66	54	69	54	78	44	85	30	75	24
Total P.	72	53	53	52	64	48	64	27	68	38
Total A.	71	53	73	47	78	35	85	25	63	18
Total All	143	106	126	99	141	83	149	52	131	56
	Underestimations of Height and Overestimations of Width									
H. P.	5	17	17	19	10	14	10	22	3	13
H. A.	24	15	15	18	5	19	5	22	7	13
V. P.	9	24	4	23	4	26	3	25	1	17
V. A.	19	26	14	21	6	19	8	23	6	18
Total H.	29	32	32	27	15	33	15	44	10	26
Total V.	26	50	16	44	10	45	11	48	7	35
Total P.	14	41	21	42	14	40	13	47	4	30
Total A.	43	41	29	39	11	38	11	45	13	31
Total All	57	82	50	61	25	78	26	92	17	61
	Overestimations of Height and Underestimations of Width									
H. P.	0	3	0	2	0	1	1	3	2	1
H. A.	0	0	0	1	0	0	0	1	1	4
V. P.	0	0	0	2	0	2	1	1	6	0
V. A.	0	1	0	2	0	0	0	2	5	7
Total H.	0	3	0	3	0	1	1	4	3	5
Total V.	0	1	0	4	0	2	0	3	11	7
Total P.	0	3	0	4	0	3	2	4	8	1
Total A.	0	1	0	3	0	0	0	3	6	11
Total All	0	4	0	7	0	3	2	7	14	12
	Totals									
Over H&W	42	47	67	54	80	76	77	89	80	111
Under H&W	143	106	126	99	141	81	149	52	131	56
U.H.O.W.	57	82	50	61	25	78	26	92	17	61
O.H.U.W.	0	4	0	7	0	3	2	7	14	12
	Naïve and Trained Combined									
Over H&W	89		121		150		166		191	
Under H&W	249		225		222		201		187	
U.H.O.W.	139		111		103		128		78	
O.H.U.W.	4		7		3		9		26	

Total cases 1200, 60 judgments of each block in each position or method

Table VI

Median Squaring Trained Subjects

	Block 1 H	Block 1 W	Block 2 H	Block 2 W	Block 3 H	Block 3 W	Block 4 H	Block 4 W	Block 5 H	Block 5 W
					Subject R. K.					
H.P.	77.5	95.6	89.3	103.0	109.0	114.0	120.0	122.0	143.0	130.0
V.P.	100.0	114.0	112.0	129.0	117.0	116.0	132.0	123.0	122.0	100.0
H.A.	97.5	115.0	110.0	126.0	113.0	125.0	137.0	130.0	147.0	130.0
V.A.	100.0	116.0	111.0	131.0	129.0	124.0	136.0	122.0	120.0	102.0
					Subject C. W.					
H.P.	99.6	108.0	95.0	102.0	95.9	98.2	94.4	95.0	93.0	100.0
V.P.	82.1	92.5	78.3	90.0	81.7	90.0	76.7	80.0	86.7	90.0
H.A.	90.0	115.0	80.0	93.0	90.8	96.5	88.9	95.0	105.0	108.0
V.A.	91.7	109.0	80.0	95.9	77.5	83.8	77.9	96.7	93.3	98.5
					Subject T. P.					
H.P.	82.5	94.4	91.1	107.0	85.0	95.0	91.1	103.0	86.7	95.0
V.P.	79.6	89.0	90.0	100.0	80.8	85.0	80.0	86.7	86.7	92.5
H.A.	80.8	89.4	95.6	104.0	72.4	82.5	97.3	81.7	85.0	103.0
V.A.	75.4	85.0	90.0	100.0	82.5	88.9	82.2	86.7	93.0	100.0
					Subject W. W.					
H.P.	72.9	80.6	73.9	85.0	88.2	101.0	105.0	118.0	98.3	120.0
V.P.	99.6	89.4	86.1	96.7	85.8	98.7	91.1	107.0	102.0	110.0
H.A.	61.7	72.5	69.9	82.5	78.3	95.0	87.8	107.0	98.3	122.0
V.A.	62.5	71.9	80.0	86.7	106.0	104.0	120.0	112.0	147.0	140.0
					Subject M. R.					
H.P.	77.5	87.5	75.5	83.3	80.0	82.2	73.3	71.7	76.7	65.0
V.P.	91.7	100.0	81.7	84.4	87.5	86.2	88.9	75.0	102.0	70.0
H.A.	91.2	103.0	92.2	107.0	101.0	100.0	104.0	96.7	113.0	97.5
V.A.	103.0	105.0	88.9	95.0	97.5	96.2	97.8	96.7	120.0	80.0

Table VI (Continued)

	Block 1		Block 2		Block 3		Block 4		Block 5	
	H	W	H	W	H	W	H	W	H	W
					Subject E. N.					
H.P.	103.0	98.7	112.0	110.0	110.0	111.0	116.0	122.0	137.0	125.0
V.P.	88.5	95.0	106.0	108.0	102.0	102.0	100.0	103.0	113.0	105.0
H.A.	107.0	108.0	120.0	117.0	113.0	117.0	110.0	113.0	123.0	115.0
V.A.	102.0	100.0	119.0	111.0	115.0	105.0	112.0	107.0	137.0	113.0
					Subject K. S.					
H.P.	84.2	87.5	93.9	103.0	98.8	119.0	108.0	132.0	128.0	152.0
V.P.	85.8	88.1	91.1	96.7	91.7	107.0	95.6	108.0	93.3	105.0
H.A.	82.5	90.6	83.3	99.1	98.8	120.0	100.0	120.0	115.0	135.0
V.A.	63.3	73.1	71.7	83.3	72.5	90.1	34.4	100.0	90.0	112.0
					Subject R. W.					
H.P.	83.3	95.0	90.0	100.0	83.3	96.2	82.2	98.3	80.0	90.0
V.P.	103.0	95.0	103.0	117.0	85.9	97.5	85.7	96.7	90.0	87.5
H.A.	57.9	70.0	52.2	68.3	50.0	67.5	51.1	70.0	55.0	80.0
V.A.	70.0	85.0	55.9	73.3	48.3	67.5	70.7	110.0	55.0	82.5
					Subject D. P.					
H.P.	77.5	85.0	83.9	95.0	89.1	95.0	88.9	91.6	102.0	100.0
V.P.	56.3	78.7	57.2	79.2	56.7	75.5	51.1	71.7	61.7	85.0
H.A.	75.8	83.6	75.0	85.0	70.0	72.5	67.8	75.0	80.0	80.0
V.A.	67.2	75.0	73.9	79.2	77.5	70.0	83.3	67.3	88.3	65.0
					Subject H. B.					
H.P.	113.0	129.0	128.0	147.0	143.0	160.0	140.0	158.0	133.0	157.0
V.P.	117.0	139.0	117.0	141.0	136.0	159.0	133.0	155.0	147.0	190.0
H.A.	94.2	101.0	104.0	114.0	124.0	134.0	117.0	127.0	138.0	140.0
V.A.	90.8	96.2	90.0	104.0	95.9	115.0	100.0	120.0	115.0	130.0

Table VII

Overestimations and Underestimations
Trained Relative to Naïve Percents

	Block 1 H	Block 1 W	Block 2 H	Block 2 W	Block 3 H	Block 3 W	Block 4 H	Block 4 W	Block 5 H	Block 5 W
All Subjects, Positions and Blocks										
H.P.Tr.	-13.7	-3.7	- 6.7	4.0	-1.8	7.0	2.0	11.0	7.8	13.4
N.	- 5.0	1.0	- 7.0	1.0	-5.0	5.0	-5.0	10.0	0.0	15.0
V.P.Tr.	- 9.5	-1.9	- 7.8	4.0	-7.3	2.0	-6.5	.7	.5	13.6
N.	-10.0	3.0	-12.0	3.0	-9.0	5.0	-5.0	10.0	0.0	10.0
H.A.Tr.	-16.0	-5.1	-10.8	- .4	-8.9	1.0	-3.9	1.6	5.9	11.1
N.	- 7.0	3.0	- 5.0	8.0	-1.0	17.0	4.0	20.0	10.0	20.0
V.A.Tr.	-17.5	-9.4	-13.9	-4.1	-9.7	-5.5	-3.6	1.9	5.8	2.4
N.	-17.0	2.0	-16.0	1.0	-7.0	12.0	-5.0	16.0	3.0	15.0
Av. Tr.	-14.2	-5.0	- 9.8	.9	-6.9	1.1	-3.0	3.8	5.0	10.1
Diff.Tr.	9.2		8.9		8.0		6.8		5.1	
Passive Method										
Trained	-11.6	-2.8	- 7.3	4.0	-5.0	4.0	-2.2	5.9	4.1	13.5
Diff.	8.8		11.3		9.0		8.1		9.4	
Naïve	- 7.5	2.0	- 9.5	2.0	-7.0	5.0	-5.0	10.0	0.0	12.5
Diff.	9.5		11.5		12.0		15.0		12.5	
Active Method										
Trained	-16.7	-7.2	-12.4	-2.2	-9.3	-2.3	-3.7	1.8	5.8	6.8
Diff.	9.5		10.2		7.0		5.5		1.0	
Naïve	-12.0	2.5	-10.5	4.5	-4.0	14.5	-5.0	19.0	6.5	18.0
Diff.	14.5		14.5		19.5		18.5		11.5	
Horizontal Position										
Trained	-14.8	-4.4	- 8.7	1.8	-5.3	4.0	- .9	6.3	6.8	11.8
Diff.	10.4		10.5		9.3		7.2		5.0	
Naïve	- 6.0	2.0	- 6.0	4.5	-3.0	11.0	- .5	15.0	5.0	17.0
Diff.	8.0		10.5		14.0		15.5		12.0	
Vertical Position										
Trained	-13.5	-5.7	-10.8	- .05	-9.0	-1.7	-5.0	1.3	3.1	8.0
Diff.	7.8		10.3		7.3		6.3		5.0	
Naïve	-13.0	2.5	-14.0	2.0	-8.0	9.0	-5.0	13.0	1.5	12.5
Diff.	15.5		16.0		17.0		18.0		11.0	
All Positions and Methods Combined										
Trained	-14.4	-5.0	- 9.8	.9	-6.9	1.1	-3.0	4.0	5.0	10.1
Diff.	9.4		10.7		8.0		7.0		5.1	
Naïve	- 9.7	2.2	-10.0	3.2	-5.5	9.7	-2.7	14.0	3.2	15.0
Diff.	11.9		13.2		15.2		16.7		11.8	
All Subjects Combined										
Tr.& N.	-12.1	-1.6	- 9.9	1.1	-6.2	5.4	-2.4	8.9	4.1	12.5
Diff.	10.5		11.0		11.6		11.3		8.4	

(For example, -13.7, the first figure in column one, means that trained subjects underestimate height in the horizontal passive method 13.7%. The first figure in column two means that trained subjects underestimate width of Block No. 1 3.7% in the horizontal passive method.)