A TACHISTOSCOPIC STUDY OF THE DIFFERENTIATION OF PERCEPTION.

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A. B. College of Emporia, 1930

Submitted to the Department of Psychology and the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

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May 9, 1931

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The writer wishes to express his indebtedness and gratitude to Dr. H.R. De Silva, Dr. R.H. Wheeler, F. Theodore Perkins and S. Howard Bartley for their advice, criticism and suggestions during the experiment. A note of appreciation is also well deserved by the many observers, who so generously gave of their time and interest.

TABLE OF CONTENTS

PURPOSE

The purpose of this experiment was to make a qualitative tachistoscopic study of the perceptual processes, giving particular note to the changes observed in a simple ink drawing as it is differentiated from a homogeneous field, and to relate the results of this experiment to the conclusions of investigators in other fields of behavior.

HISTORY

Perception has already been the subject for thousands of investigations. In spite of the heterogeneity of the experimenters' apparatus, technique and assumptions, these researches have born very uniform results. The purpose of this section is to review a few of the experiments most closely related to the study herein reported.

In an early study, Cattell found that with an exposure time of 0.08 seconds, 4 or 5 letters could be seen and reproduced accurately, but that if the letters were made into words and exposed for the same time, 12-15 could be reproduced. Similar results were obtained by Erdmann and Dodge (4) who found that words of 22 letters could be perceived very well, but that 7 letters which did not form a word could not be accurately perceived. In the same way

if the three parts of the letter K were presented separately, reproduction was difficult and inaccurate, while if the K itself were presented, there was no difficulty in reproducing it.

With the above facts as a basis, Wiegand(13) conducted an experiment in which he employed words of varying lengths as stimuli. His reproductions showed (1) shortening, (2) first part of the word was seen more often than the last, (3) the stem was seen more often than the prefix or suffix, (4) transposition of letters, (5) people knew the length of the word better than the individual letters, (6) simplification, (7) proper names were easier than variable words, and (8) completion, with or without change of letters. Ex., individualisieren was reproduced as indualiseren, darmreizung was seen as darmzeitung.

Whipple (12) approached the problem of perception differently by studying the effect of practice on the range of visual attention and visual apprehension. He exposed cards to his observers for varying lengths of time, and obtained the following results. (1) Range of attention is not affected by practice, except as the observer learns to group materials. (2) The average limit of the range of attention is between 4 and 5 impressions. (3) There was only a slight gain in the amount seen at six seconds

(6.3 impressions) over what is seen at 0.08 seconds (4 or 5 impressions). (4) The greatest change between a short and long exposure was a change in the range of attention.

Dickinson (3) showed figures to his observers for various brief periods of time, and from his results concluded that there are three levels in the progress of experience. (1) Visual pattern. "A thereness, clear in contour but lacking in logical meaning. Things seen but not identified. A flat appearance." (2) Generic object. Parts begin to stand out in sharp relief... to emerge from the general field. Forms take on general meaning. (3) Specific object. Forms take on stability. They have specific characteristics and logical meaning. The rest of the field fades. Dickinson stresses the fact that these levels are not separate but that they are "steps in a progression". He also mentions the fact that sense data may be obliterated by imagery which arises to the level of specific object.

Smith (10) on the other hand believes that there are two stages in the process of perception. "There is first (a) an immediate interpretation of the object as a whole, and next (b) an anlysis of this vaguely apprehended whole into its component parts". In the first process there is a striking uniformity while in the second there is no less striking variability.

One of the most recent and valuable studies was made by Snygg (11), who presented his observers with a series of cards bearing from 5-9 asymmetrically arranged numbers. After each exposure, his subjects reproduced as accurately as possible what they had seen. His results show (1) 99.87% of the reproductions had changes toward increased stability of pattern; (2) an equalization of distances between numbers; (3) increased symmetry; (4) according to introspective reports this process is not an accompanying phenomenon but an essential part of the apprehension process; (5) the initial phases of perception are not aggregates of discrete elements, but a unified, relatively homogeneous field, and (6) that there is a tendency toward closure.

It is interesting to note that experiments in memory yield results similar to those observed in the immediate reproduction of visually perceived patterns. Wulf (14) showed his observers a series of simple diagrams which were reproduced after various periods of time. He found what he termed levelling: as an omission, toning down or weakening of a characteristic, sharpening: exaggeration or emphasis of a characteristic or peculiarity, and structurally conditioned changes.

With similar materials, but a different method of presentation, Gibson (5) found five types of changes

in the reproductions from memory. (1) Object assimilation: the perception of a figure involved verbal or visual imagery of some familiar object or shape, and the reproduction resembled this object more than the stimulus figure. (2) Verbal analysis: The figure was analyzed into its parts. (3) Figure Assimilation: One part of the figure is thought to be like some other part and reproduction makes it so. (4) Completion and disintegration: occurred in broken figures. (5) Rectilinearity: Curved lines were reproduced as straight.

Perkins (8) using a technique similar to Wulf, in which the stimulus figures were seen only once by the subjects, found the following types of change toward symmetry. (1) Equalization, (2) orientation, which included making vertical figures horizontal, or figures which were on an angle vertical or horizontal; making pictures vertical or horizontal when they were not; reversal or inversion with reference to the stimulus figure, (3) standard objects or geometrical figures, including changes toward a circle, oval or parts of either, and squaring, (4) simplification, (5) complication, (6) completion, (7) proportional relations, (8) bilateral symmetry, (9) whole symmetry.

These reviews furnish us with a number of facts. 1. Perception is a gradual, continuous progression of experience. This progression may be divided into two or more phases characterized by definite attributes. 2. There is a definite limit to the amount of material or

the number of figures which can be seen in a limited time. The ratio between the amount of stimulus material seen and the exposure time decreases rapidly as the exposure time is increased.

3. Reproductions of tachistoscopically perceived material indicate increased stability of part grouping, equalization of distances between perceived objects, increased symmetry, perception begins with a rather undifferentiated, homogeneous field, closure is common, organized material is more easily perceived than unorganized, simplification, transposition, completion, objects or words which have but one form are more easily perceived and more accurately reproduced than objects or words which vary in form.

4. Experiments in memory yield the following results: omission, or weakening of a characteristic, exaggeration or over-emphasis, verbal analysis of the perceived material, figure assimilation, completion, disintegration, rectilinearity, changes toward symmetry by means of equalization of distances, simplification, bilateral symmetry and whole symmetry.

APPARATUS

The apparatus for this experiment included a tachistoscope modeled after Dockeray and a timing device for regulating the exposure time of the tachistoscope for periods of one second or longer. A 25 watt bulb, non-frosted, furnished the light, Of the many bulbs that were tested this type had the fastest heating and cooling time, each taking less than one tenth of a second. For exposures of less than a second, a camera shutter capable of making "Bulb", "Time", 150th, 100th, 50th, 25th, 5th, $\frac{1}{2}$, and 1 second exposures was employed. For exposures of a second or greater the more complicated device was used. (See Plate I for sketch of apparatus, and Plate II for diagram of circuits) A kymograph drum supported by a horizontal drum support was rotated by an electric motor geared down to the proper speed. On the circumference of the drum was a non conducting paper from which four strips had been cut thus exposing the conducting surface of the drum itself. A pointer of flexible metal, supported by a rod stand, pressed against the paper on the drum, or the drum itself in those cases where the strips of paper had been removed. When the pointer came into contact with the metal surface of the drum, it completed a 3 volt circuit which magnetized a relay, thus closing the 110 volt

circuit and lighting the bulb on the tachistoscope. As the kymograph drum continued to turn, the flexible metal pointer once more moved on the paper, breaking the circuit and turning out the light on the tachistoscope. Since the strips cut from the paper on the drum represented one, two, three, and four seconds of exposure time, it was possible to automatically regulate the tachistoscopic exposure time. The minor circuit was provided with a switch that made possible a continuous rotation of the motor and drum without exposing the slides in the tachistoscope before the observer was ready. The shutter was put on "Time" and left open whenever this timing device was in use. For the shorter exposure times, when the shutter was used, the 110 volt circuit was closed with a cut-off switch lighting the bulb continuously. This furnished 1.8 foot candles of light, although at an exposure time of 150th of a second it was psychologically slightly less.

All of the apparatus except the tachistoscope and the case which held the stimulus slides was on a second table. It was originally planned to group all pieces of apparatus on one table, but the vibration of the motor proved a distraction. On the second table it was possible to cover the motor and gearing with a heavy padded cardboard box which deadened the sound, making it negligible.

LEGEND

A. Tachistoscope

a. Bulb

b. Camera Shutter

B. Switch

C. Relay

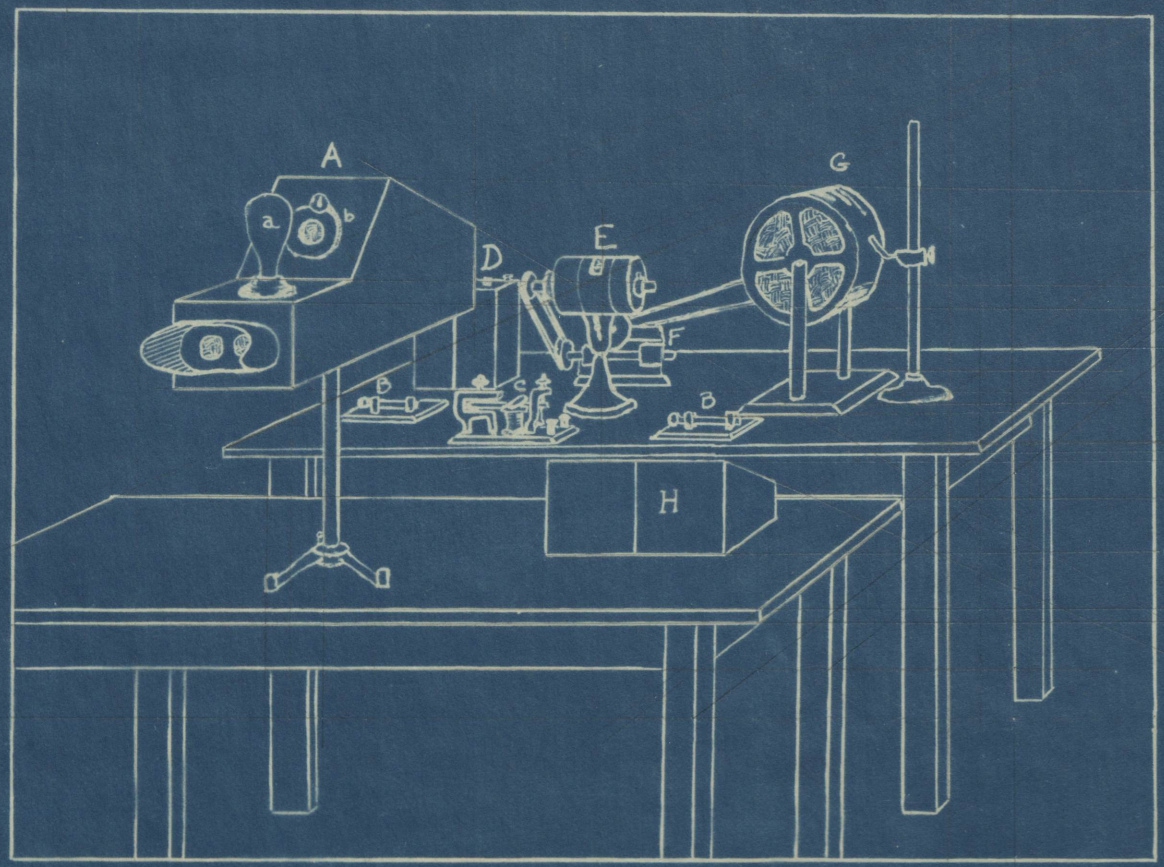
D. Battery

E. Electric motor

F. Gearing

G. Kymograph timing device

H. Slide tray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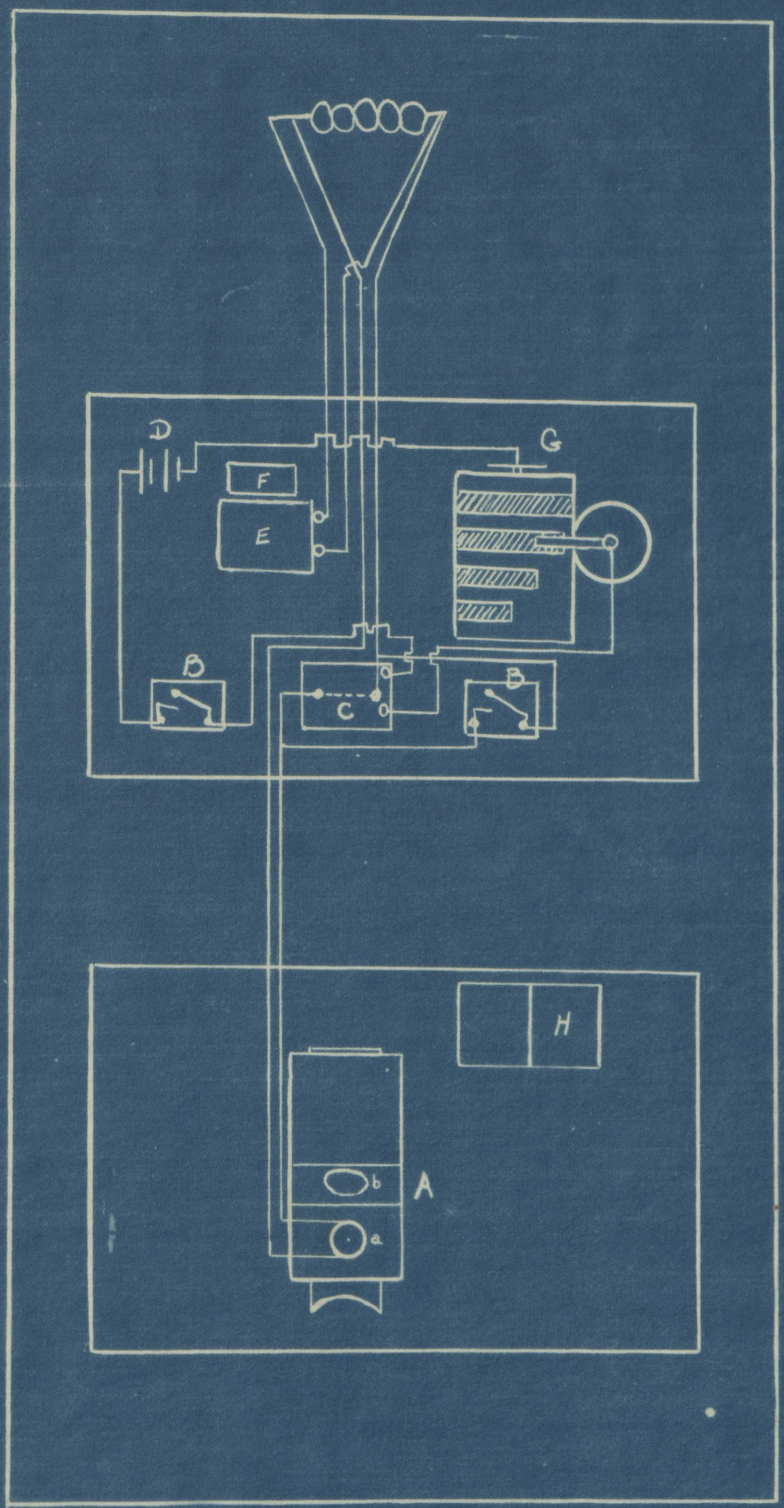
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METHODS

There were four parts to the experiment.

In Part I. a series of 20 stimulus cards, 4 inches by 5½ inches bearing simple geometric figures within a 2" by 3" area were shown to 60 observers at 5 different exposures times. Twelve observers saw them one 150th of a second; eleven saw them at one 100th of a second; fourteen saw them at one 50th of a second; eleven at one 25th of a second and twelve observers saw them at one 1/5th of a second.

The observer was seated before the tachistoscope and the following instructions given him.

"I am going to show you a number of slides with various simple drawings on them. You are to look into the tachistoscope before you and see as much of each slide as possible. When the light goes off each time, you are to reproduce what you saw as accurately as you can. In case you don't see what something is, but do see where it is, represent it with an X. Your score for each picture will depend on the accuracy of your reproduction of it. I will say 'Ready', 'Now', and will then expose the slide for a very brief time. When I say 'Ready', hold yourself tense and direct all of your energy toward the eyepiece so as to see as much as you can. Are there any questions?... All right, ... 'Ready! etc."

One second was allowed to elapse between the "Ready", and "Now" and the time the shutter was clicked. The observer was given as much time as he wanted to make his drawing.

After the third exposure, he was asked to tell all he could about the process... to mention everything he had seen, and any changes that had occurred between the time the card became light and when it returned to complete darkness. The introspections were recorded and the experiment continued. When all twenty of the cards had been seen and reproduced the observer was given another chance to introspect, and to tell anything additional which he had noted.

Part II was mainly a check experiment on Part I. The experimenter desired to learn whether certain results of Part I had been the result of the stimulus cards used, or whether some general principles appeared. We prepared 18 new slides including different figures which contained the same type of material which had brought forth the interesting results in the first part. Nine of the second series of cards (Group A) were shown at one 150th of a second and the second nine (Group B) bearing different figures but corresponding in type were exposed for one half second. After 10 sets of results had been obtained,

the two groups were reversed, so that the other 8 observers saw Group B at one 150th of a second and Group A at ½ of a second.

The results of Part I clearly indicated that an exposure time greater than one fifth of a second would be necessary in order to gain reproductions which would even approximate the stimulus figures. Part III aimed not only to find what changes occurred after 1/5th of a second, but to trace each observer through from one 150th of a second to 4 seconds. A new set of cards was prepared, 32 in all, and four of them (one containing 6 numbers, one containing 6 letters and the other two having simple figures) were exposed 1/150th of a second, 4 at 1/25th of a second, another four at 1/5th and so on at ½, 1, 2, 3, and 4 seconds. Thus changes could be noted in the differentiation of numbers, letters and line drawings at eight steps from 150th of a second to 4 seconds.

In the fourth part of the experiment, the observers were shown the same stimulus cards which had been used in Part III and were allowed to see them as long as necessary "in order to make a perfect reproduction". The light was turned on with the same starting signals as had been used in the first three parts, and was left on until the observer had signalled that he had seen it long enough. They then made their reproductions.

METHOD OF SCORING

An unavoidable fault of the scoring was its subjectivity. The writer attempted to make it as objective as possible by marking all the reproductions himself, doing them all at once, going back and rechecking a set now and then in order to be sure that values were not changing too much, and using as constant a set of values as possible.

Each reproduction was scored for accuracy on the basis of ten. Since most of the stimulus cards contained 6 elements, lines, numbers or letters, six points were allowed for the material itself. A reproduction of a card containing 6 letters, where only 4 of them were remembered, would be given four points in the scoring. Another two points was given for the gross grouping and the other two points were allowed for relational or more minute grouping. Thus the card containing only four of the six letters might have X's in the exact location of the two letters not accurately distinguished. It would thus be possible for that reproduction to be scored 4 points for material, 2 for gross grouping and if the finer relations were reproduced, one or two more points.

In studying the reproductions for the presence of symmetry, complication, simplification etc., one point was given for each reproduction in which one of these

characteristics was present. A more accurate method of scoring would give credit for the amount of change as well as the mere fact of its existence.

Although the scoring method is not perfect, it is fairly uniform for all the reproductions and gives an accurate relative grade to all.

SUBJECTS OF THE EXPERIMENT

From all four of the experiments we have 115 sets of observations, representing 2768 reproductions. Some of the subjects served in more than one experiment, so that the total number of subjects was approximately 100.

In Part I there were 60 observers of which 8 were professors and instructors, 9 graduate students and 43 undergraduates.

In Part II there were 16 observers including 2 professors, 1 graduate student and 13 undergraduates.

In Part III there were 21 observers: 1 professor, 2 graduate students and 18 undergraduates.

Part IV had 21 subjects: 1 professor, 6 graduate students and 14 undergraduates.

The professors were all trained psychologists; the graduate students with the exception of one graduate student in physics and one student in the medical school, were all psychology majors working for advanced degrees. The undergraduates were either enrolled, or had been enrolled, in at least one class in psychology. The factors of age and sex were ignored.

RESULTS

The quantitative results of Part I are summarized on the following page. The most obvious changes were toward symmetry, simplification, complication and transposition. Changes toward symmetry occurred by four general means: improved grouping, bilateral symmetry, improved symmetry within the parts, and completion of incomplete figures.

We were surprized to find, not a steady increase in the amount of accuracy of the reproductions but a drop in the accuracy curve beginning at about one 100th of a second. At one 150th of a second the accuracy of all reproductions averaged 30.9%, at one 100th of a second the average accuracy was 38.9%, at one 50th of a second 34%, at one 25th of a second 33.6%, and at one fifth of a second the accuracy was 30.75%. A glance at the reproductions would indicate an even greater change in the direction revealed by the statistics.

Both the drawings and the introspections substantiate the results of the experiments by Snygg, Dickinson and Smith. The first stage in perception is a vague "thereness". It is at first totally undifferentiated, and gradually develops until the general outline or form is discernable. Reproductions of plates seen at this period show great simplification of minute detail and com-

Types of change	1/150 sec. Av.	%	1/100 sec. Av.	%	1/50 sec. Av.	%	1/25 sec. Av.	%
I. Symmetry	15.1	83.3	16.2	90	16.7	92.7	17.3	96.1
A. Grouping	9.3	77.5	8.33	69.4	9.78	81.5	10	76.9
B. Bilateral	4.8	40	3.8	31.7	3.4	28.3	6	50
C. Part Relation	11.4	60	15.7	82.6	15	79	15.9	83.6
D. Completion	3.1	44.3	1.72	24.5	2.42	34.5	3.09	44.1
II. Simplification	15.5	71.5	11.9	62.6	8.14	42.8	9.45	49.7
III. Complication	7.4	37	2.81	14	3	15	3.7	18.5
IV. Transposition	2.2	31.4	1.36	19.42	.64	9.14	.72	10.2

1/5 sec. Av.	%
17.2	95.5
7.4	61.6
4.25	35.4
12.3	64.7
2.25	32.1
8	42.1
3.16	15.8
1.16	16.5

plication of gross structure. For instance in the case of stimulus cards 1 and 2, (following page 30) instead of 3 rows of four squares each, the reproductions would inducate that 5 or 6 rows of 6 or 8 squares had been seen. This process of differentiation continues, until at about one 100th of a second, the best gross reproductions are gained. A period follows which yields much poorer drawings. In Part III of the experiment it was seen that the low period ends anywhere from 1/5th of a second to 2 seconds, and from that time the accuracy improves as differentiation occurs. For the material used in this study the very best reproductions were made by those observers who saw the stimulus cards at the average of 6.6 seconds.

Typical Observations.

U 19. "The picture is vague at first, then definite lines stand out, seeming a little in front of the white background. Then in the afterimage the figure is very clear for an instant and then disappears. Form comes after a general impression. The larger parts are more clearly defined at first than the smaller parts."

U 6. "Saw more than I reproduced, but it was so vague I couldn't verbalize it or reproduce it."

E 4. "I saw a white ground first, immediately followed by popping out of figures simultaneously, which came out

in groups. Then individuals emerged from the group. Position comes before identity of number. I am sure that I grouped the material more symmetrically than it was in the stimulus card, but don't know how. I immediately organized the material into patterns. Memory becomes exclusively patterned. Saw big things first and small later."

U 17. "See general pattern followed by individual particulars."

E 5. "Saw figures largely in the after image."

E 3. "See squares shift transversely to form stable and familiar patterns. Things become very symmetrical in the after image. There is always somethings about every figure that stands out."

U 4. "See first the group of black outlines always as a group, then follows the process of differentiation, in which the parts are perceived in relation to the first unitary impression. There is a rapid expanding movement of the white background which grows to maximum and then recedes. In trying to form a memory image there is a conflict quite frequently between ideas of what is perceived and elements that were never actually perceived apparently forcing themselves into the mental picture."

U 11. "Saw the general form first. Then I tried to make a mental inventory of the parts. See some of them in the real image and some in the after image."

Several of the observers saw the stimulus cards at the briefer exposure times and wrote "something more" or "something forgotten" on their drawings. There were many more introspections expressing the same ideas, but those preceding will serve as samples. The preceeding introspections clearly indicate that there is a difference between what an observer perceives and what he reproduces. The reproduction of the visually minded observers are probably more closely correlated with what was seen than are the reproductions of the auditory minded individual. Since in this experiment it was impossible to measure the perception directly we are forced to use the observer's reproductions as our criterion of the accuracy of perception.

Other facts of some importance accrue from the data of Part I. Subjects employed several methods in simplifying their drawings. Some of these were (1) leaving out lines which were not neceasary to make a complete figure, (2) adding parts in order to make the figure symmetrical and easier to memember, (3) changing relations so that they were similar through out the figure, (4) putting meaning and reading order into the figure. For instance No. 7 of the stimulus figures was likened to a honeycomb, with the result that the reproduction U 19 (18) was made similar to the subjects memory of a honeycomb.

Approximately 50% of the subjects made use of

one type of symmetry much more than any other type. The alteration of relations between lines or parts of the figure was the predominant method of symmetry employed.

There were a great many more cases of complication at one 150th of a second than at any other exposure time. Thirty seven percent of the reproductions of figures seen at 1/150th of a second showed complication while the next highest percentage was 18.5% at one 25th of a second. The amount of complication per figure was likewise greater at 1/150th of a second than at any other time.

There was more difference between the observers in any one time group than between different groups as wholes. In spite of this it was possible to find averages within the groups which would distinguish them from the averages of other groups.

Approximately 5% of the drawings were changed toward greater symmetry after apparent completion. The observer would make his reproduction and then as he looked at it, it would seem too asymmetrical and he would change it toward symmetry.

Regardless of how long observers looked at the stimulus figures, if they could not verbalize what they saw, it was impossible to make a good reproduction. One nonsense figure was used in Part I of the experiment, and

the reproductions of it showed greater variation from the stimulus figure than was indicated by any other reproductions. Two observers indicated the following. No matter how brief the exposure time, if they could see the material long enough to put it into words they could reproduce it. Sometimes they would see the material but it would fade before they could differentiate it to the extent of verbalization.

Mental set is demonstrated very well by some of the reproductions. In Part I, the first three cards contained squares in various positions. The fourth stimulus card contained straight lines of various lengths and the fifth was a series of part circles, non-concentric. Observer U 8 attempted to express the general form of plates 4 and 5 in terms of squares. Another interesting example is furnished by the reproductions of Observer A 7 in Part II. Stimulus card No. 14 was recognized and reproduced as a dog. Card No. 15 contained 4 circles each of which bore 3 lines. Her reproduction of No. 15 showed four dogs, the same in form as the one on Stimulus Card No. 14. One of the most interesting and common examples of the effect of mental set is furnished by Sample Stimulus Card No. 16, in which there is an inverted 4, and below it an upright 9. Almost 30% of the reproductions of this made an inverted 6 in place of the upright 9. See Sample Reproduction II, 2 as an illustration.

At least a dozen of the observers mentioned the fact that they forgot the material before they could reproduce it in a drawing. To avoid this difficulty the experimenter directed three of the subjects, E3, U 4, and U 3 to reproduce the stimulus figures without taking their eyes from the tachistoscope. This technique was used with the hope that if the subjects saw nothing but the inside of the tachistoscope, they would be able to remember what they had seen of the stimulus material and reproduce it more accurately. The plan failed due to disturbing factors resulting from the method. In the first place, none of the subjects were accustomed to drawing without seeing what he was doing, and the result was often a maze of lines which meant nothing. Also, the subjects tended to visualize the movements of the pencil on the paper. This caused them to forget the stimulus figure that they had just perceived. Another factor which prevented the success of the plan was that the afterimage underwent so much change that it served as a distraction rather than an aid in drawing.

The purpose of Part II was to verify the results obtained from Part I. One of the stimulus cards in Part I had contained the four Playing Card symbols. The reaction of many of the observers was to say, "Oh, I know what that is", and to look away from the tachistoscope immediately. The result was a set of inaccurate reproductions. The

subject could neither visualize the stimulus objects nor recall them in their correct order. The purpose of Part II was to learn whether the card containing the playing card symbols had been inaccurately reproduced because the material was exceptionally difficult, or whether recognition involved a loss of differentiation of detail. Six simple, easily recognized objects as a bottle, cup, fork, and dog were used as stimuli. Three were exposed for one 150th of a second and the other 3 for 1/2 second. If the observer recognized the figures when the exposure time was $\frac{1}{2}$ second, he would overlook or misrepresent the details in 56 % of the reproductions. With an exposure time of one 150th of a second, the subjects would overlook or misrepresent the details in 79% of their reproductions.

The 19th stimulus card of Part I pictured three rectangles each containing 2 crosses. In 70 % of the cases where the observer saw that there were X's in the rectangles three instead of two were reproduced in each. In orderto learn whether this was caused by the particular card or if it were a general practice of making the smaller parts, equal in number to the larger parts, several triangles or circles containing a number of parts different from their own number were presented at 1/150th and 1/2 second. When the stimulus cards were seen for $\frac{1}{2}$ second, the observers would indicate an equal number of large and small figures in 25% of their

reproductions. At the exposure time of 1/150th of a second the observers reported an equal number of large and small figures in 13 % of the reproductions. Both of the above percentages would have been considerably higher if only those cases had been considered in which the observer saw what was within the figures. Particularly at 1/150th of a second many of the drawings merely had wavy lines or a group of dots to represent something within the circles or triangles. The material had differentiated only to the "thereness" stage.

Another fact indicated by the reproductions was that a series of intersecting lines appeared to be more complicated and less orderly than it really was. Part II tested this condition. A series of 6 cards was exposed for long and short periods in order to ascertain whether the observers would complicate their reproductions if the stimulus cards contained drawings which were too complex to be readily grasped. When the exposure time was $\frac{1}{2}$ second, the observers made 37% of their drawings more complicated than the stimulus figures. At 1/150th of a second 29% of the drawings indicated increased complication. These figures are not really high enough to indicate a tendency unless it is realized that normally the observers simplify the figures in their reproductions. It is probable that this complication is a mechanism of simplification. In the fraction of a second that the observer sees the stimulus card

he is able to perceive only a mass of lines arranged in a general pattern. He does not know the position of the individual curves or lines. He must therefore continue to add lines to his reproduction until his pattern resembles as nearly as passible his memory of the stimulus figure. Because the observers drawings are arranged more simply than the stimulus material, it will take a greater mass of lines to represent an equal complexity of design. With but few exceptions the observers simplified the pattern of the drawing in their reproductions and in order to stimulate the appearance of the stimulus figure between 29% and 37% complicated their sketches.

In Part I it appeared that some parts of a stimulus figure were seen at the expense of other parts. To test this more directly, figures like No.9 and No. 10 of the Sample Stimulus figures were used. Eighty seven per cent of the reproductions of figures seen at $\frac{1}{2}$ second showed that one element was emphasized at the expense of others. Ninety seven per cent of the peproductions of figures seen at 1/150th exhibit the same phenomenon.

Part III traced the growth of perception in each of 21 observers, from 1/150th of a second to 4 seconds. Since the same changes of symmetry, simplification, complication and transposition appeared in the reproduction in this part as in Part I nothing will be said about them. The problem to be considered is the change in the per cent. of accuracy at different exposure times. The following

table summarizes the gross average of improvement of accuracy between 1/150th of a second and 4 seconds.

Exposure time	Percent. accuracy
1/150	37.3
1/25	43.3
1/5	44
1/2	45.8
1	56.7
2	67.8
3	69.5
4	75.4

While this shows the gradual improvement of accuracy with time, it does not illustrate the changes in any one individuals work. The following table presents the statistics for each observer.

PERCENT. OF ACCURACY OF REPRODUCTIONS AT VARIOUS EXPOSURE TIMES.

Observer	1/150	1/25	1/5	1/2	1	2	3	4
N1	30.	40.	25.	45	40.	47.5	60	55
N2	37.5	42.5	32.5	42.5	45	72.5	70	72.5
N3	15	32.5	30	32.5	52.5	35	65	75
N4	40	40	57.5	42.5	60	82.5	76.5	82.5
N5	35	40	27.5	50	55	72.5	65	85
N6	35	37.5	35	42.5	52.5	60	60	65
N7	42.5	50	55	55	60	72.5	75	90
N8	35	50	42.5	47.5	70	85	77.5	75
N9	42.5	55	60	67.5	62.5	90	85	85
N10	52.5	55	37.5	45	57.5	67.5	82.5	80
N11	22.5	32.5	40	37.5	85	76.5	80	85
FA1	40	57.5	42.5	52.5	50	55	67.5	82.5
FA2	35	47.5	47.5	55	60	52.5	72.5	80
FA3	35	40	47.5	52.5	47.5	60	70	65
FA4	42.5	52.5	57.5	55	65	77.5	65	80
FA5	35	35	40	47.5	65	67.5	65	72.5
FA6	52.5	57.5	55	50	57.5	67.5	75	77.5
FA7	32.5	35	37.5	32.5	30	45	35	60
FA8	37.5	47.5	60	42.5	67.5	85	85	85
FA9	47.5	32.5	42.5	47.5	65	72.5	65	70
FA10	37.5	30	50	42.5	42.5	52.5	62.5	60

These figures and the drawings from which they are taken seem to indicate 3 phases in perception. The first is a phase of gross vision, in which objects are seen by their general outline, and differentiation is slight. Then a phase occurs in which perceptions are less stable and the reproductions of stimulus material are less accurate. Two of the observers reached this stage at 1/25th of a second, 9 reached it at 1/5th of a second, 8 reached it at 1/2 second and 2 reached it at 1 second. The third phase continues from the end of the second, to 6.6 seconds for such material as was observed in this experiment.

On the following pages will be found the accuracy curves of the 21 observers in Part IV. Three types of curves appear. There are those which are a constant upward progression; some curves characterized by one drop in accuracy and those which have two drops in accuracy. Only 2 of the 21 curves climb consistently. One of these, N.7, has a plateau in the 1 second region where the majority of the curves decline; the other, FA 5, has a 2 second plateau between 1 and 3 seconds. Only four of the curves show one drop, and in each case it appears under one second. The remaining 15 curves have two descents, one at some exposure time under 1 second, and the other during the remaining 3 seconds.

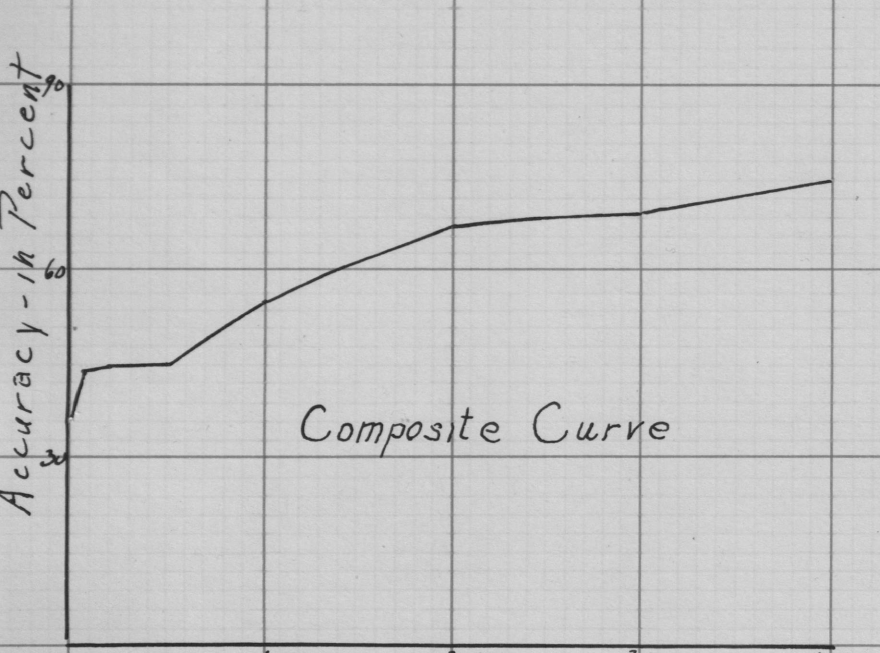
Approaching the study of the curves a little differently we find that 19 of the curves (all of those which had any descent) have a decline at some exposure time under one second. Of the fifteen curves which had 2 declines, 3 occurred between 1 and 2 seconds, 8 occurred between 2 and 3 seconds and 4 occurred between 3 and 4 seconds.

As the experiment was conducted there was no means of ascertaining whether the declines which occurred after one second were the result of the material used or whether there is a second unstable period in the reproduction of perceived forms.

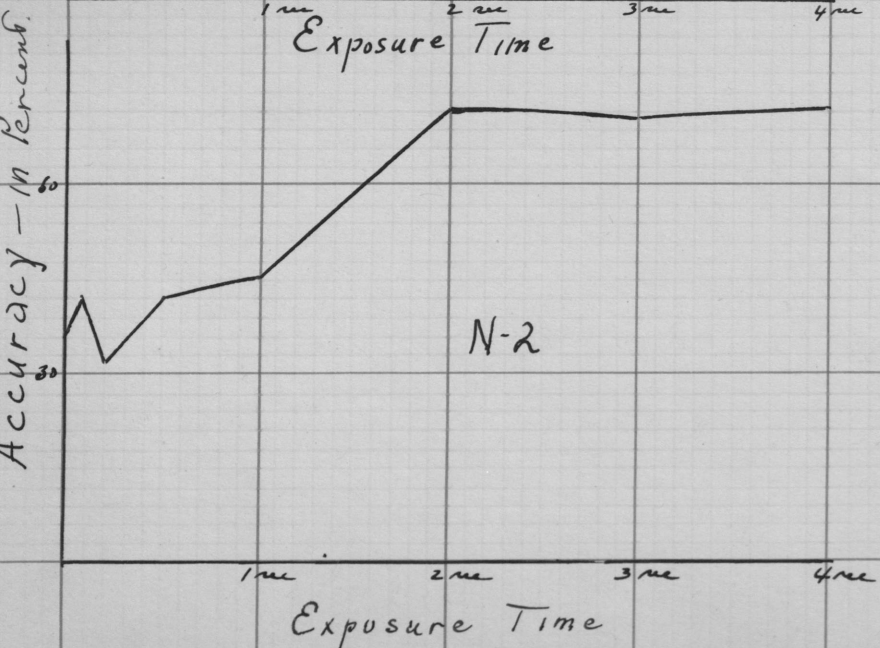
The most apparent fact is that there is always a decline or plateau at some time less than one second, and the results of this part of the experiment indicate that there is usually a second decline in accuracy appearing before the perception is complete.

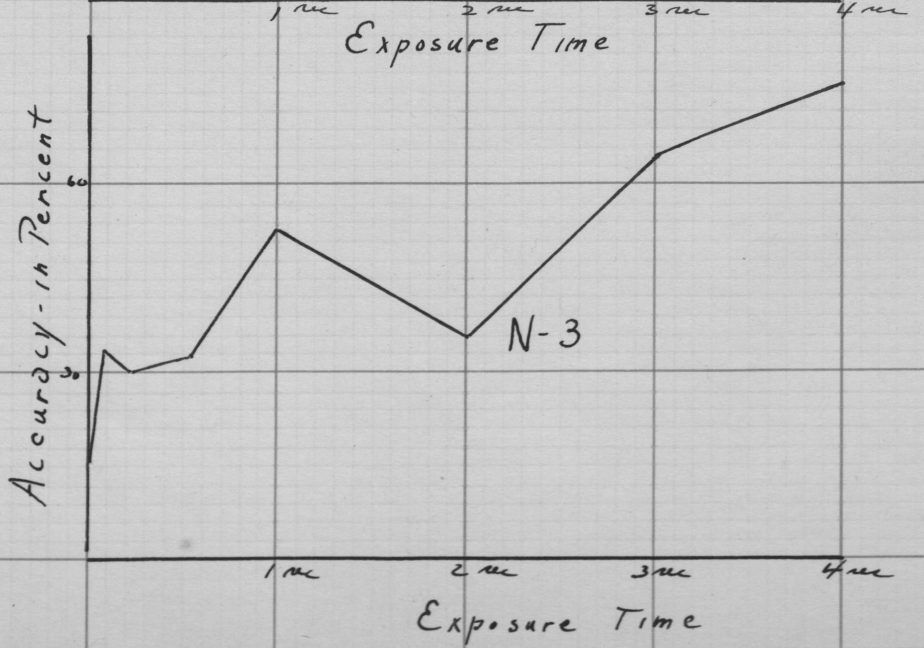
The graph on page 30 pictorially presents the relation between exposure time and the accuracy of reproduction of the stimulus material in Part III of the experiment. The upper curve traces the total changes of accuracy at the eight exposure times, and the lower curve represents the amount and correctness of stimulus

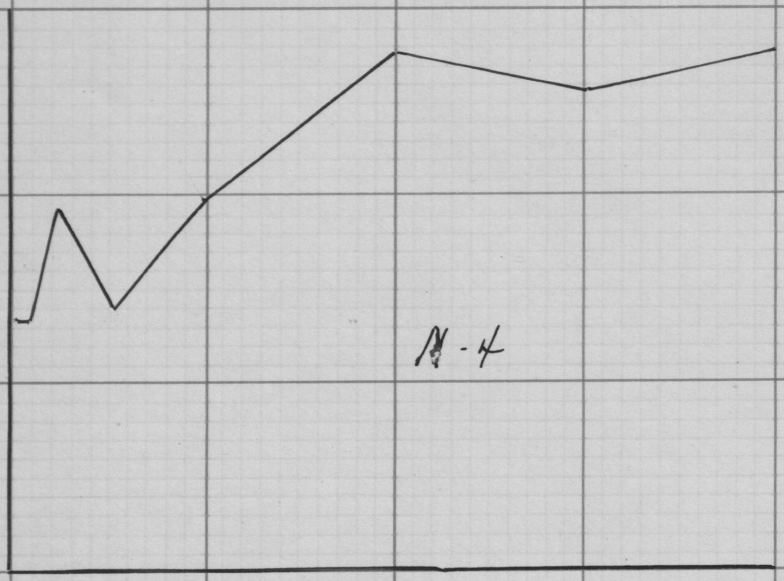
material seen. The difference between the height of the two curves at any point indicates that part of the total score for accuracy which was allowed for exactness of reproduction of relations between different parts of the stimulus figures. An interesting fact exposed by these curves is that the increase of accuracy is more rapid for the parts of the drawings (lines, numbers, letters, etc.) than for the relations between these parts.


Accuracy - in Percent
90
60
30
Composite Curve
1 sec
2 sec
3 sec
4 sec
Exposure Time

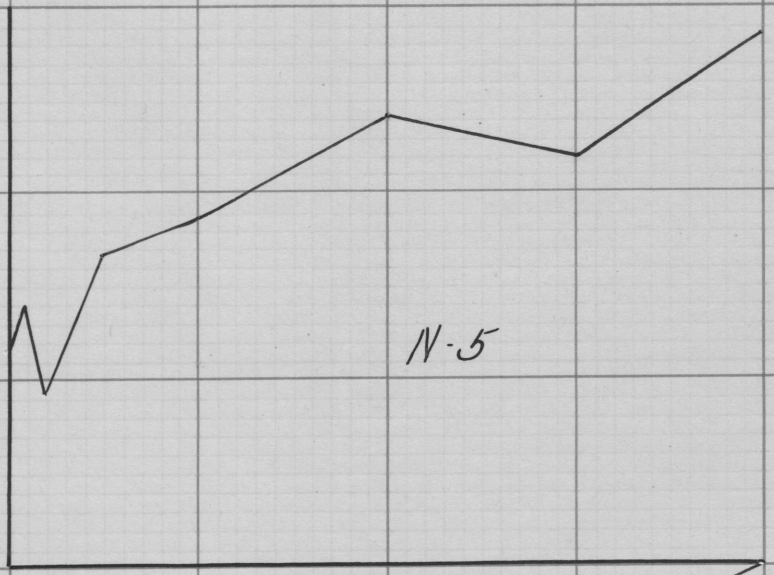

Accuracy - in Percent.
90
60
30
N-1
1 sec
2 sec
3 sec
4 sec
Exposure Time


Accuracy — in Percent.
60
30
N-2
1 sec
2 sec
3 sec
4 sec
Exposure Time

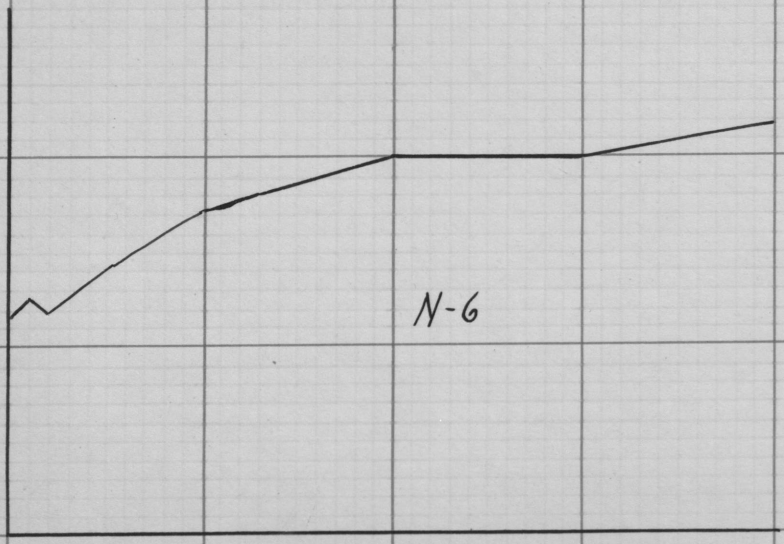

Accuracy - in Percent
60
30
N-3
1 sec
2 sec
3 sec
4 sec
Exposure Time



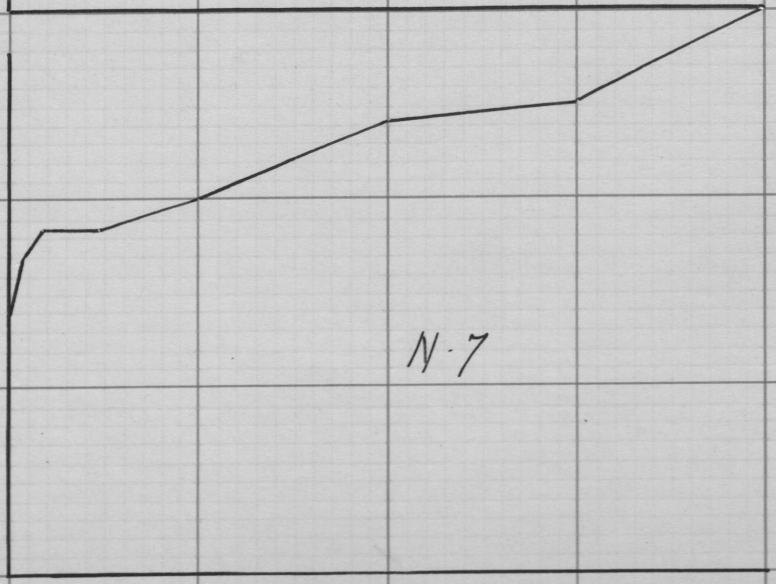
N-4



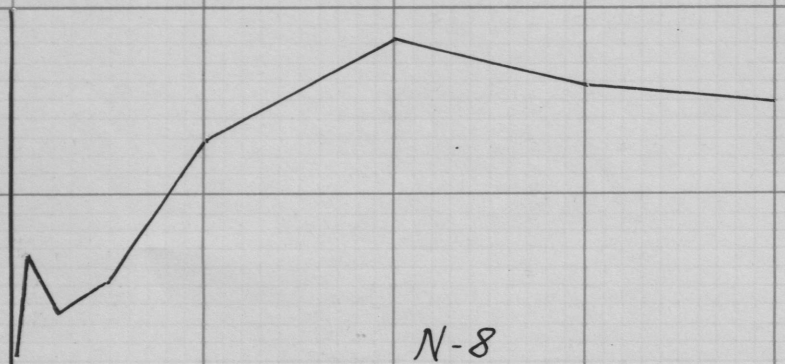
N-5



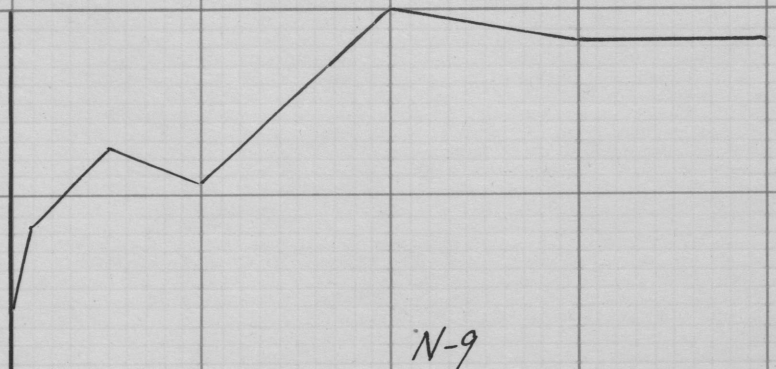
N-6



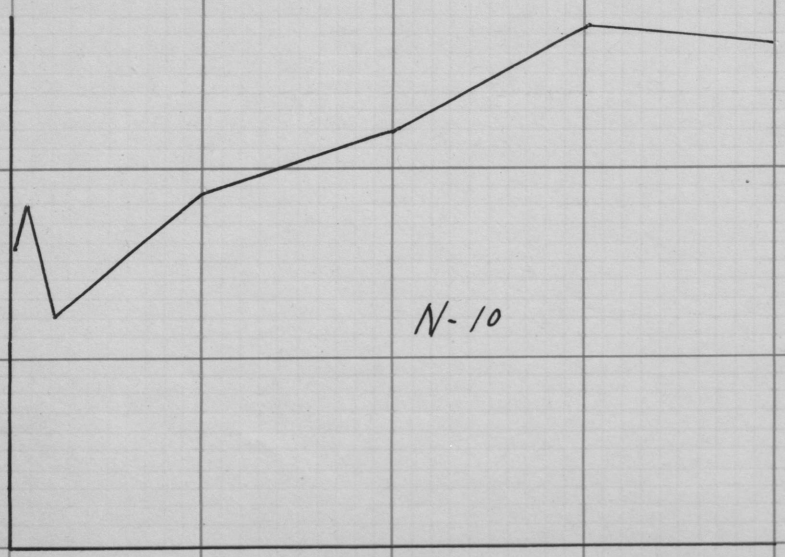
N-7



N-8

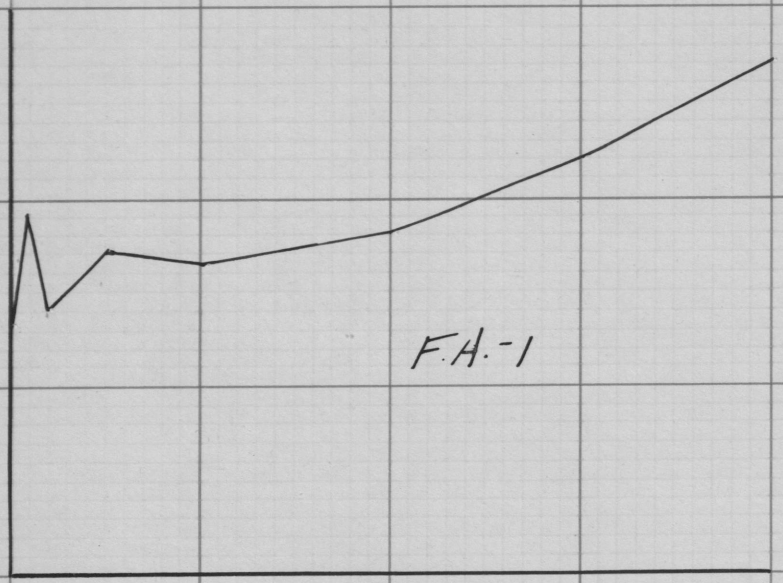


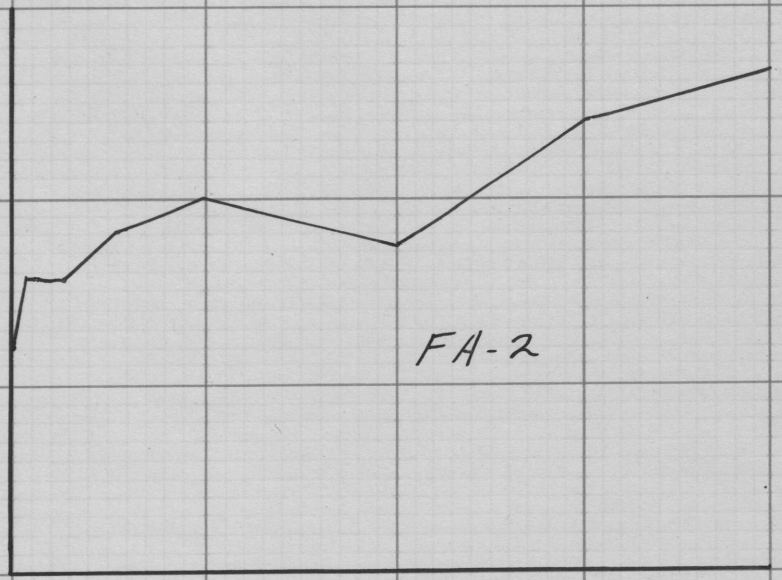
N-9



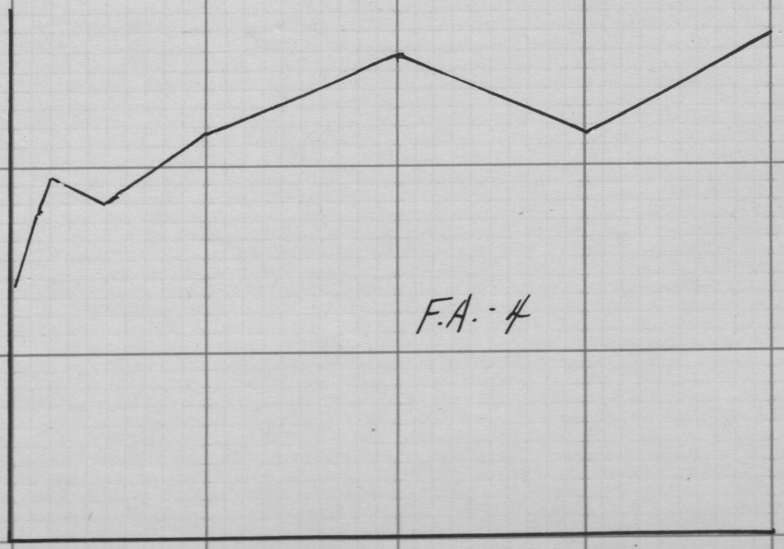
N-10

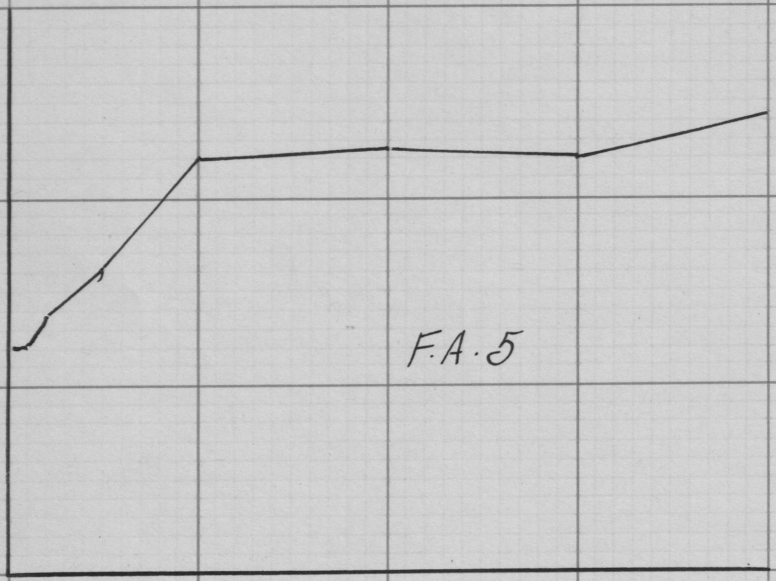
N-11


F.A.-1

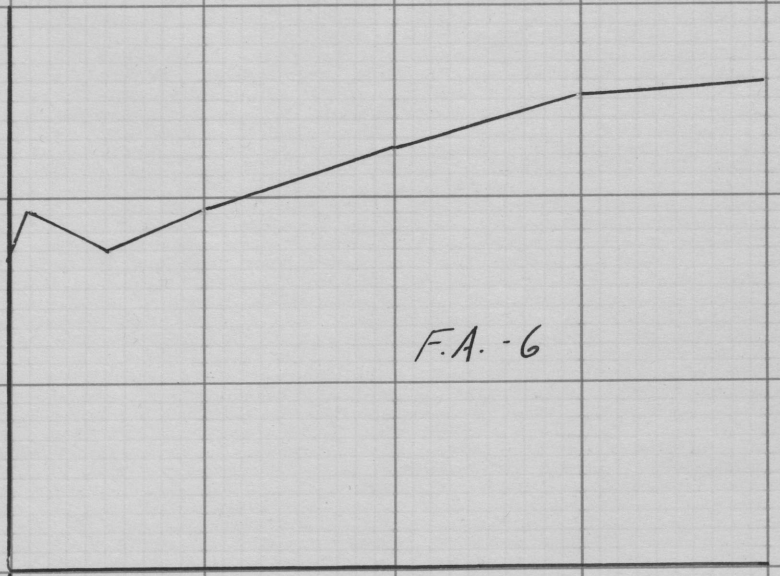

FA-2


F.A. 3

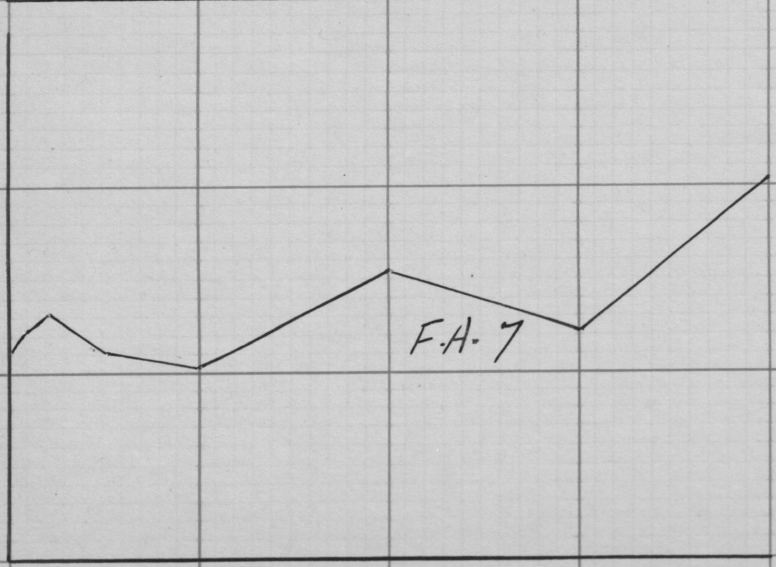

F.A.-4



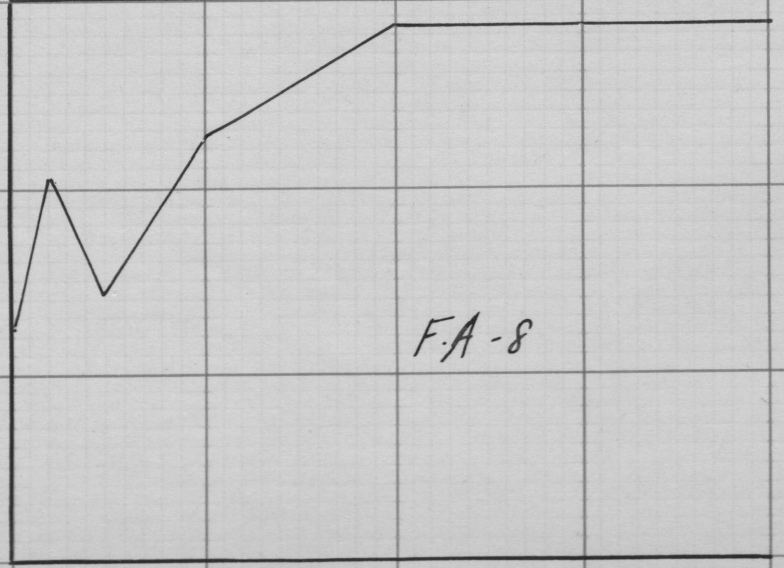
F.A.-5



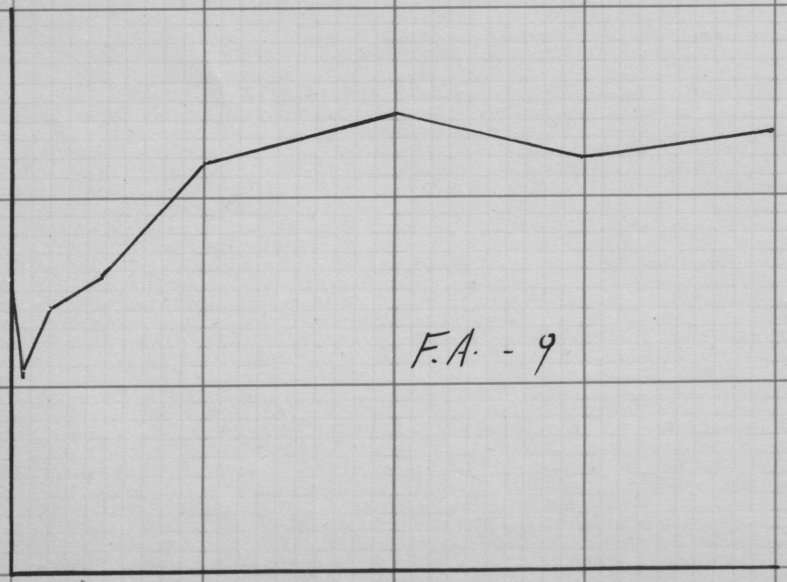
F.A.-6



F.A.-7

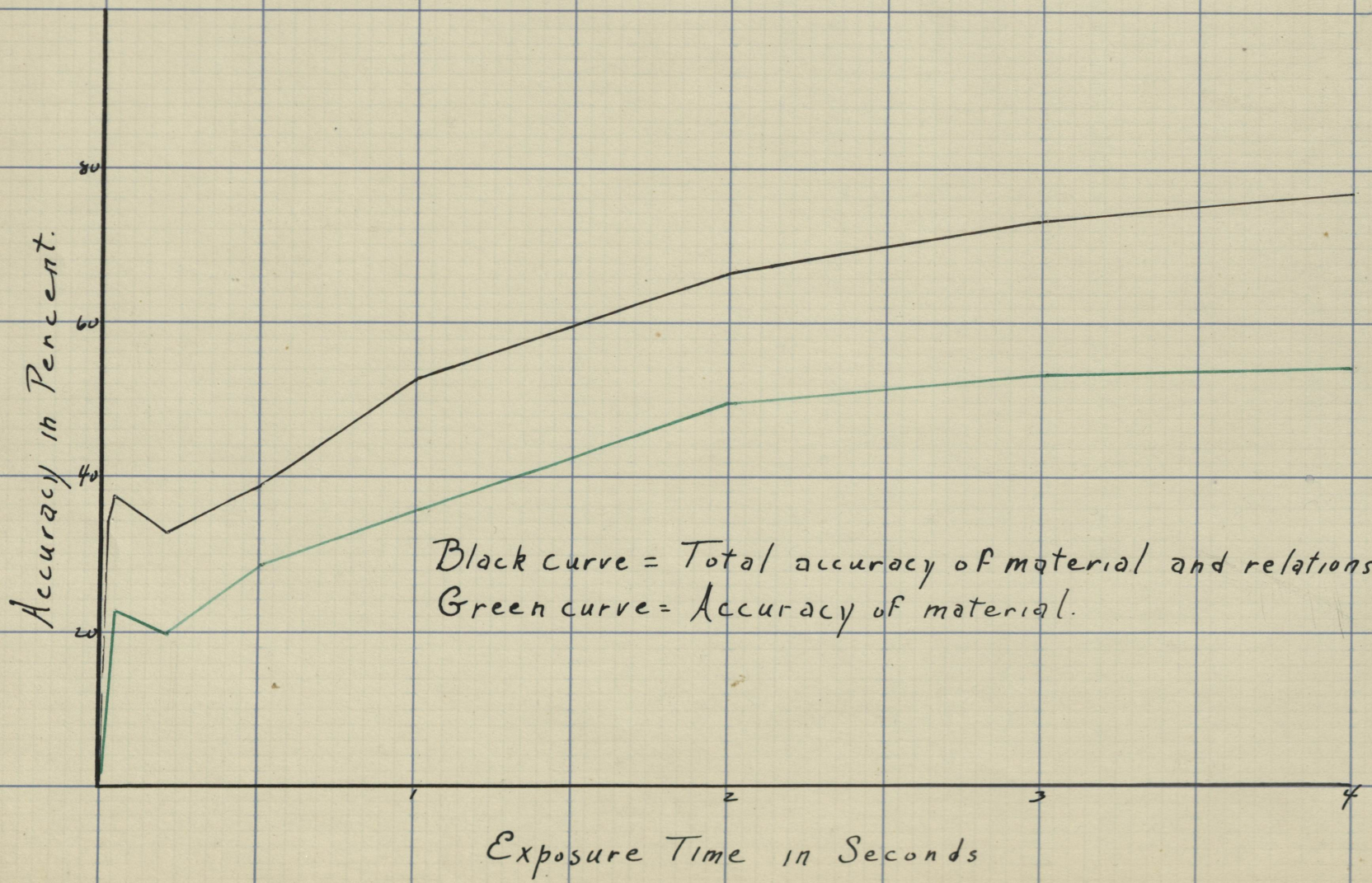


F.A-8



F.A. - 9

F.A. - 10


Accuracy in Percent.
80
60
40
20
1
2
3
4
Exposure Time in Seconds
Black curve = Total accuracy of material and relations
Green curve = Accuracy of material.

Part IV of the experiment was largely a quantitative study of the length of exposure required by an observer in order to make a maximumly accurate reproduction of perceived material, and to ascertain the per cent. of correctness of drawings made under these conditions. The table on the following page gives a comparative survey of the average exposure time for stimulus cards containing numbers, letters and simple drawings for students in the college (N) and students in the school of design (FA). Although the design students perceived the picture in less time than the college students, the average accuracy is about equal for the two groups, with the college students slightly higher due to the fact partly that one of the design students fell very low in accuracy.

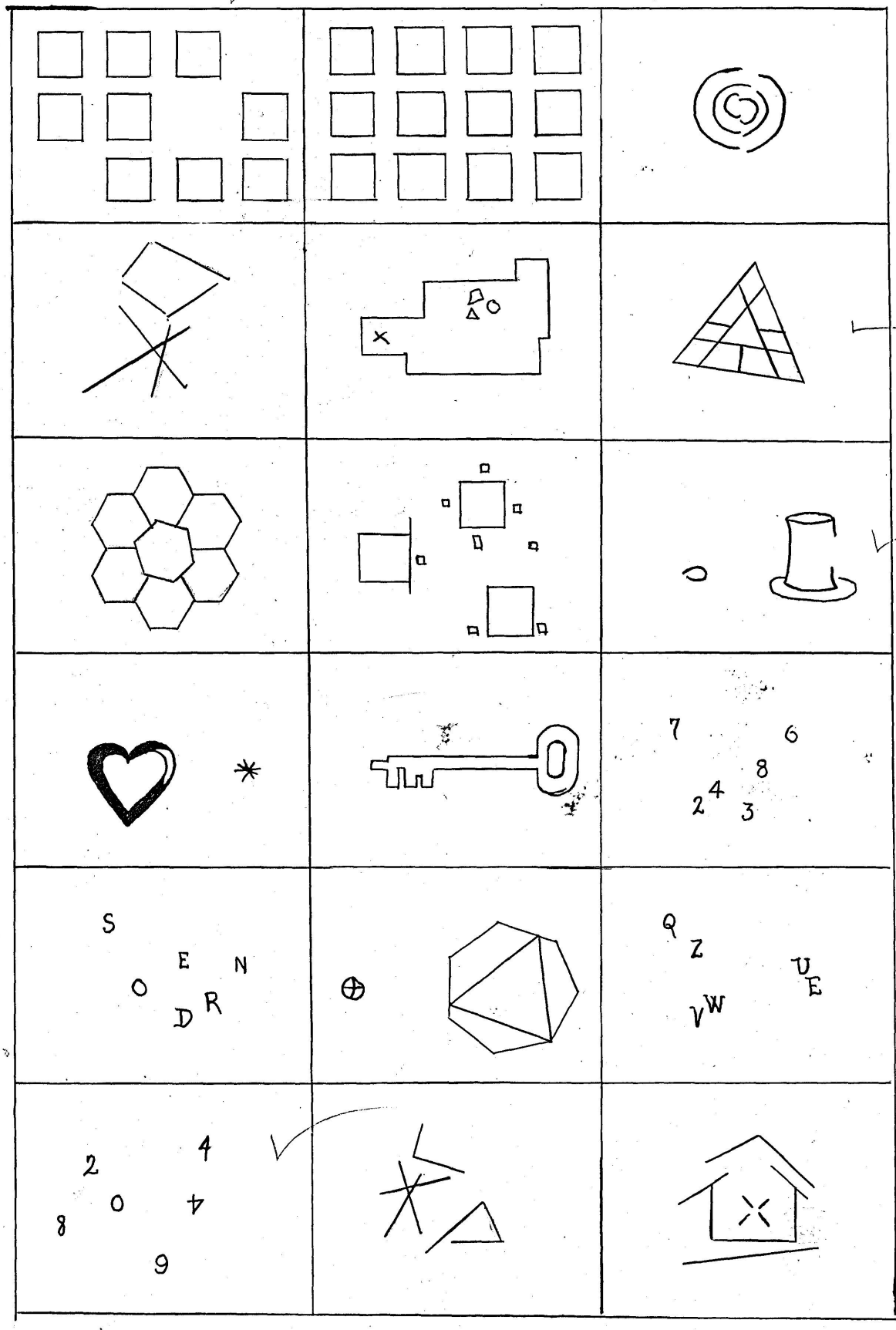
Number N	Average Time	Average % Correct	Time Numbers	Time Letters	Time Pictures	% Correct Numbers
1	8.5	85.6	7.38	9.09	9.05	88.7
2	13.32	88.3	12.47	15.97	11.51	86.2
3	5.49	87.9	6.52	5.88	4.07	91.8
4	5.54	92.28	4.87	5.75	6.02	96.2
5	8.7	83.7	7.87	8.31	9.93	86.2
6	4.8	81.2	4.31	5.57	4.55	83.7
7	9	82.4	7.81	10.25	9	85
FA						
1	6	85.8	5.68	6.1	6.21	87.5
2	6.69	87.2	7.03	7	6	88.7
3	6.14	57.8	6	6.87	5.56	67.5
4	4.21	90.8	3.4	4.87	4.37	92.5
5	4.25	82	3.75	4	5	82.5
6	4.27	85.8	3.75	5.25	3.8	85
7	6	78.3	6.56	6	5.5	80
8	4	80.5	3.5	4.5	4.25	83.3
9	6.35	85.5	5.75	7	6.3	90
10	6	85	6	5.6	6.62	85

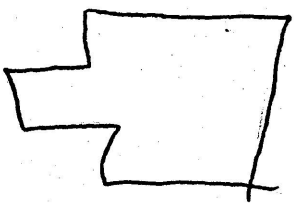
% Correct Letters	% Correct Pictures
85	83.1
85	93.7
86.8	85.3
93.7	86.87
83.7	81.3
82.5	77.5
80	82.3
80	90
85	88
45	61
85	95
85	78.7
85	87.5
82.5	72.5
83.3	75
80	86.5
85	85

SAMPLE STIMULUS CARDS

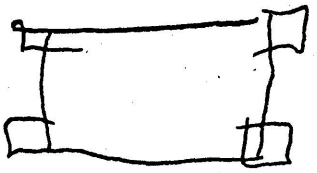
and

SAMPLE REPRODUCTIONS

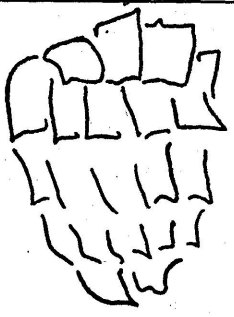

S
E
N
O
D
R
7
6
8
2
4
3
Q
Z
U
E
V
W
2
4
0
8
9



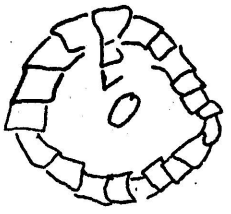
E5-11 Too Simple 1.



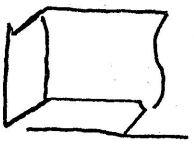
U6-11 2.



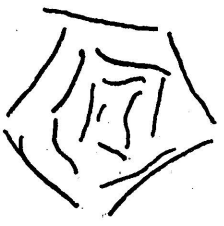
U19-18 3.



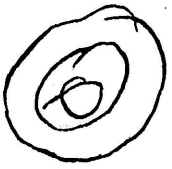
U45-18 4.



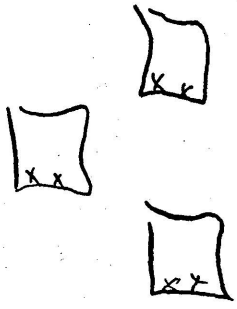
U19-6 5.



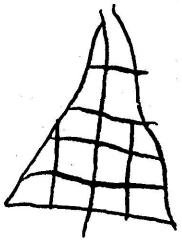
U44-6 6.



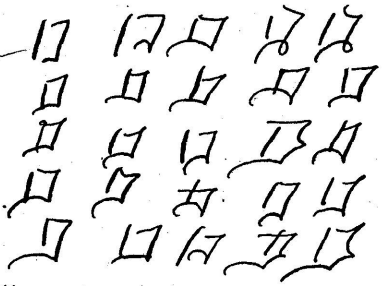
U6-5 7.



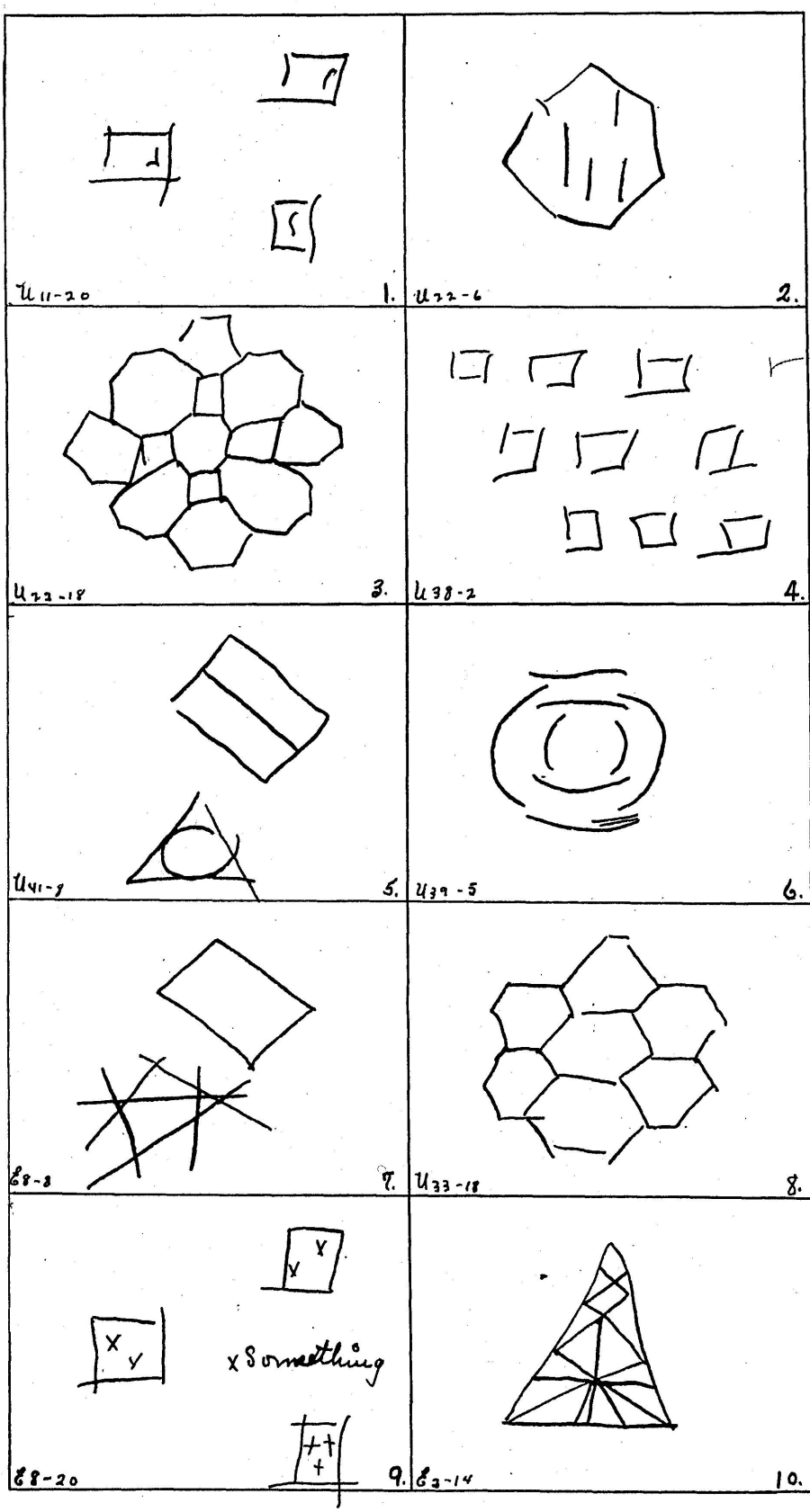
U19-20 8.

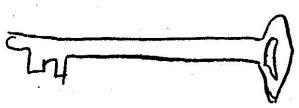


U5-14 9.

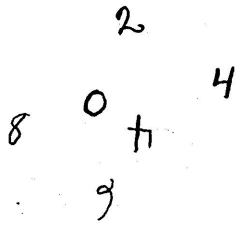


U44-2 10.

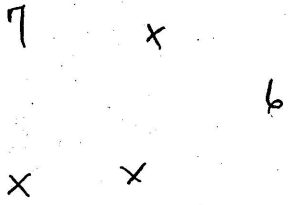

U11-20
1.
U22-6
2.
U22-18
3.
U38-2
4.
U41-9
5.
U39-5
6.
E8-8
7.
U33-18
8.
X
Y
Y
Y
xSomething
E8-20
9.
E3-14
10.



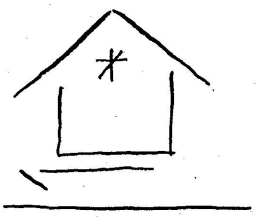
A2-2 1.



N4-18 2.

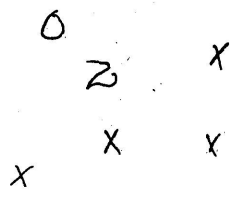


N5-1 3.

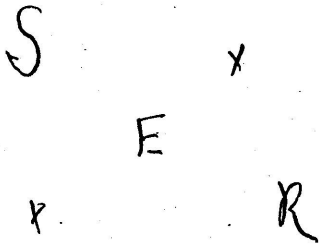


7.A-4-11 4.

A6-8 5.

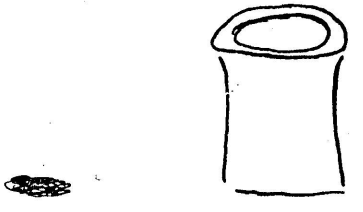


9A1-6 6.

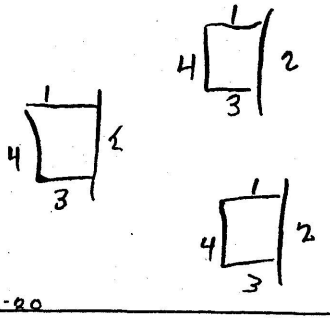


N8-2 7.

N7-19 8.



A4-8 9.



N9-20 10.

DISCUSSION AND CONCLUSION

One of the first facts to be demonstrated by the experiment was that perception, under the conditions of this research, is the differentiation of a homogeneous field in such a way that the parts emerge already unified and patterned. Both the introspective material and the reproductions of the drawings substantiate this. Not one of the 2768 reproductions made by the observers was lacking in some sort of organization. The pattern was perceived before its content was identified. Perhaps the clearest illustration of this observation is furnished by the reproductions of cards containing numbers. Sample Reproductions III, Nos. 3, 6, 7 show that the location, grouping or order was perceived although the numbers were not known. Illustrations with different materials are furnished on the same page (III) by Nos. 8 and 9. The grouping in No. 8 is quite accurate, but the figures themselves are very inaccurately recorded. No.9 is the reproduction of a top hat, with part of the right side omitted, (see Stimulus Card No.9) The hat was not recognized as a hat, but it was locatediin the proper place in the reproduction, and the little egg at the side was correctly placed. Plate I, No. 3 and Plate II, No.3 which are reproductions of Stimulus Card No.7, confirm the thesis that organization is primary. Further evidence is presented by the observers introspections.

"I saw a white ground first, immediately followed by popping out of figures simultaneously." "See first the group of black outlines always as a group." "Saw the general form first. Then tried to make a mental inventory of the parts." "The squares appear first in a group, then I begin to differentiate into the number of squares and their arrangement." "My first impression is of a white field against which various figures rest."

Both the drawings and the introspections are very definite evidence that this patterning is not a conscious adding or organizing or synthesizing of parts. It occurs before the parts are identified. One observer whose vision was deficient, was never able to analyze the stimulus figures to the extent of recognition of the parts. His reproductions are merely wavy lines, or circles or triangles corresponding to where the figures were, not what they were. The same was true, but usually less obvious in all the reproductions where differentiation was slight. From these facts we conclude that the field is perceived as a whole, and that the relative location of the parts of the figure is differentiated first.

Ease of differentiation and speed of perception are roughly proportional to the degree to which the stimulus material is symmetrically arranged. Sample Stimulus Card

No. 2 is perfectly symmetrical. It was reproduced more accurately than any other stimulus card. Ninety three and three tenths per cent of the reproductions of this card were correct in principle, although some observers added or neglected to record one row of squares. Sample Stimulus Card No. 1 differs from No. 2 by the absence of three squares, making the former asymmetrical. Only 3.3% of the observers reproduced No. 1 correctly, and 94% of the subjects made their drawings more symmetrical than the stimulus figure. Some of the observers filled in the three missing squares and made their drawing identical to Stimulus Card No. 2. Others suggested the figure by making three rows of squares, each row being a little farther to the right of the figure than the tow above it. (See Reproduction I, 4) Stimulus Card No. 3 was reproduced very often as 3 or 4 concentric circles, or if the breaks were noticed, concentric circles were represented in which there was a break at the top or bottom.

The most common methods employed to improve the arrangement of material, and to simplify the reproduction were (1) to equalize distances: Compare Reproduction I, 1 with Stimulus Card 8. (2) to complete imcomplete figures; Compare Stimulus Card 4 with Reproduction I, 5. (3) to omit parts which are not necessary for symmetry and completeness; as the omission of small squares in Reproduction

I, 1. (4) to repeat one characteristic in place of a different but correct one; Compare Stimulus Card 14 with Reproduction II, 5. (5) to center or balance parts which are off center or off balance; Compare Reproduction I, 8 with Stimulus Card No. 7. (6) to use bilateral symmetry; Compare Stimulus Card 3 with Reproduction I,6. (7) To transpose a part which is not in close relation to other parts until it becomes so; Compare Stimulus Card 8 with Reproduction III, 10 (Small squares)

The results of this experiment, substantiate the results of both Dickinson, who divided perception into the three levels of Visual Pattern, Generic Object, and Specific Object, and Smith who divided perception into two stages (1) the immediate interpretation of the object as a whole and (2) analysis of the whole into its component parts. Neither of these investigators discovered the fact which is perhaps the most striking outcome of this experiment.

The graph on page 36 shows that the changes in the accuracy of reproduction of perceived material with respect to form and position is not a steady, upward curve, but is characterized by a drop in accuracy at a point usually occurring under one second. To simplify our discussion, we shall call the initial phase, in which there

is only a gross differentiation, Period I. Period II will extend from the point at which the accuracy of perception seems to decrease to the point at which improvement again appears. This point will mark the beginning of Period III which continues until the maximum accuracy of perception is attained. In the following paragraphs we shall consider minutely the details of the reproductions which are characteristic of each of these periods.

The most outstanding characteristic of Period I is the grossness of differentiation. Large groupings. large objects, outlines and a general impression of size and a still more general idea of content are all that is perceived. Gross relations, such as several squares forming an arc, the general plan in which numbers are arranged, the many-sidedness of a figure, with a small figure to one side are well perceived. There are fewer cases of increased symmetry in this period than in any other. What is seen is accurately seen. Gross relations are however the extent of perception in this period. Squares, circles, triangles, and similar familiar forms are also identified, but their content, or inner organization is never seen. Sample Stimulus Card No. 6 produced very interesting results. It was always recognized as a triangle, and was always seen to have something within. Not one of the 20 observers was able to discern what the simple pattern was. A typical reproduction of it is given in Plate II,

No.9. With but two exceptions, all of the observers saw that the large figure in Sample Stimulus Card No. 14 contained many sides, but the number of sides, the position of the inner triangle and the content of the small circle at the left were never reproduced correctly. The grossest and most general factors were all that could be differentiated in this period, which ends between 1/100-1/50 of a second.

The second period is characterized by a poorer gross differentiation, and the beginning of the appearance of finer parts, inaccurately perceived or remembered. Both the gross relations and the finer interrelations are distorted. Reproduction I, 10 shows that more of the inner parts are noticed than were seen in II, 9 at 1/150th of a second, but that the arrangement of pprts is very incompletely differentiated. The decline in accuracy during this period is more rapid than the rise in the following period. The decline is accomplished in 1/20 of a second or less, but the return to a level of accuracy equal to that at the end of Period I takes approximately 1/3 of a second. The period ends between 1/5 and 1 second, with the average falling about midway between 1/5th and 1/2 second.

The third period begins at the low peint at the end of the decline in Period II, and continues until from 4 to 13 seconds, with the average at 6.6 seconds.

At the end of this third phase of the curve the best possible perception under the conditions if found. In this period, arrangement and accuracy of reproduction of material improve together. When the maximum is reached, the figures are more accurate than the relations between parts, both gross and fine. The writer does not wish to intimate that he considers these values static or final. In another group of observers, or with different stimulus material the values undoubtedly would have been different.

The question immediately arises: is Period II the result of some artifact or is it genuine? Causes of error might be (1) that the material perceived during the supposed Period II was more difficult than that seen during the other two periods, (2) the scoring, (3) a period of fatigue or loss of interest in Part III, (4) a poorer group of observers in Part I.

All of these are checked by the methods of the experiment. Even if the material perceived in Period II had been more difficult in Part III, still the characteristic drop is noted in Part I where the same material was used at each exposure time, with a different group of subjects. Thus with the same material, the drop in accuracy occurred. It can not be the fault of the material. The same method of scoring was used for each exposure time, so that while absolute values might be open to criticism, the

relative values are constant throughout. Great care was taken that this be true. (See method of scoring, page 13) The drop could not be the result of the scoring. Another possible criticism would be that the subjects lost interest or became fatigued, causing the decline in the accuracy curve. There was no outward sign of fatigue and the subjects reported no loss of interest in the experiment. It is probable moreover that even had some of the observers become disinterested, their depression or fatigue would have appeared at more widely different times. There was nothing in the procedure to make the observers regain interest toward the last, in Period III. It rarely required more than 10 minutes for an observer to see all the cards and make the reproductions, and in such a brief period as this fatigue could not be an important factor. Fatigue will in now way explain the uniformly poorer reproductions made at 1/5th second in Part I of the experiment where the reproductions of a whole group of observers showed a decrease in accuracy. The last suggested criticism is that a poorer group of observers acted as subjects in Part I where the exposure time was 1/5 second. To prevent anything of this nature, more than 3 or 4 subjects never observed consecutively at the same exposure time. Three or four would observe at 1/150th of a second, then the same number would observe at 1/100th of a second and so on. With such a

technique it is very improbable that more than an average of poor observers would be placed in any time group. Also the type of observers would not explain the results in Part III where one observer went through all of the exposure times. Thus Part I and Part III acted as mutual checks on each other. We feel therefore that since the above chances for error were checked in one way or another, that the results are valid.

The results of experiments by Ebbinghaus and Meuman indicate that there is a possible similarity between the decrease in accuracy of successive learning and the decrease in accuracy of simultaneous learning as measured in this investigation. Ebbinghaus said that "As the number of syllables in a series increases, the number of repetitions required for learning increases much more rapidly in proportion to the increase in the number of syllables in the beginning while later on the opposite is true. In illustration: One exposure is needed to learn 6 syllables, 5 repetitions are required for an observer to learn 8 syllables, 10 repetitions are required for 12 syllables and 21 repetitions for 18 syllables. But only 32 repetitions are required for the learning of 36 syllables. Thus the growth of perception under successive repetitions is slow at first and then increases more rapidly like the growth of simultaneous perception.

The next problem is to explain the fact that

the growth of perception is not a constant upward curve in terms of accuracy. Our data indicate that the decreased accuracy of perception between 1/100 of a second and 1 second is caused by perceptual changes and a resulting unstable condition of the observers memory image of the perceived material. To illustrate this we will follow through the perceptual process making only such statements as can be substantiated with either the reproductions made by the observers, or their introspections.

Under the conditions of this experiment the observation begins with darkness. When the light is turned on, illuminating the inside of the apparatus and the stimulus card, the first thing that is perceived is gamma movement. Out of this general brightness indefinite shadings are differentiated. They become increasingly clear until they are recognized as rather definite forms. What changes have taken place thus far have not served as distractions, but after this point at which the best gross organization is perceived, the perceptual expansion and expansion of size of the field present a larger more complicated perception which the observer immediately starts to analyze. Objects not noted before are now seen. The size of the card, the frame of black wood in front of the stimulus card, the blackness of the interior of the tachistoscope, the nature of the card on which the stimulus figure is drawn, ink spots on the paper, and a number of

similar things show that the size of the field and the perception itself have undergone expansion and differentiation. There is a limit to which this can go, and the end of Period II probably marks the limit. Although we had no means of verifying the presence of eye movements, it is possible that they began during this period. Koffka (6) gibes 1/50 of a second as the probably time when eye movements would begin. Whatever be the mechanism, the analysis of the field continues until the maximum differentiation, under the condition, occurs.

With exposures of 1/150th of a second or 1/100th of a second the perceptual field was limited and undifferentiated. The resulting reproductions were likewise limited crude. The 1/5th or 1/2 second exposures provided ample time for eye movements, for analysis, for change of fixation, and the introspective reports and the drawings indicate their presence. Thus we have two different conditions; the first phase of perception, limited in size and differentiation and very stable, and the second phase transitional, analytical, expanding and therefore unstable. This second period is a critical phase of perception. Analysis has destroyed the whole and part differentiation is very rudimentary. The sudden stopping of perception at this point leaves the observer with only a confused idea of what he had seen. He is unable to properly relate the parts to the whole perception and the parts have not been differentiated sufficiently to become stable themselves.

Summarizing this we may say that the decline of accuracy in Period II is caused by the interruption of perception at a critical point, where analysis has divided the pattern into unstable parts. A parallel situation is furnished by Coghill (2) In describing the development of the hind limb movement of Amblystoma he states:

"Its earliest movements are, also, performed only as the muscles of the trunk contract. A day or so later it acquires the ability to execute reflexes without perceptible participation of the trunk response. Also, when flexion of the knee first occurs it is a part of the movement of the leg as a whole. Only later does it occur in response to local stimulation without perceptible movement of the thigh."

Here as in visual perception, the parts become functionally separate only as the primary whole is differentiated. At first the part responses in the Amblystoma are weak and limited. As differentiation continues they become strong and stable. In the same way the analysis of the perceptual field caused the parts to emerge, weak and unstable in Part II but continually stronger and more stable in Period III.

One of the purposes outlined for this experiment was to relate its results to those of experiments in other fields. In this experiment, more than 90 % of the reproductions were more symmetrical than the stimulus material.

The stimulus sketches were purposely arranged asymmetrically and all of the changes in the reproductions indicated improved arrangement. Experimenters both in the field of perception and in other fields have noted this increased symmetry. Snygg, Wiegand, Dickinson and Smith report its presence in their experiments on perception and Wulf, Gibson and Perkins record the same changes in their experiments on memory. The above investigators and the present writer have also found equalization of distances between perceived objects, closure, simplification, complication, completion, verbalization, and balancing of parts.

The apparent similarity between perception and memory seems to confirm the configurational theory that all behavior follows the same principles. This theory is further substantiated by the fact that all types of behavior overlap. An experiment in memory can not be conducted without the use of perception. Likewise an experiment in perception can not be conducted as this one was without the use of memory. But is not the same true of other behavior. Any experiment in learning involves perception and memory. An anlysis of any of the sensory processes will also involve perception and memory. Thus the results of this experiment and those cited above substantiate the hypothesis that all behavior follows the same principles both because of the similarities between memory and perception and the fact that perception and memory form some part of any behavior pattern.

SUMMARY

1. Under the conditions of this experiment, perception involves the differentiation of a homogeneous field in such a way that the parts emerge already unified and patterned.

2. There are three characteristics phases in the differentiation continuum as indicated by the observers reproductions.

a. Period of gross differentiation ending at approximately 1/100th of a second.

b. Period of less accurate and stable perception, terminating between 1/5th and 1 second.

c. Period of highest differentiation, reaching its maximum between 4 and 13 seconds, for the material employed in this experiment.

3. The relative location or grouping of the stimulus figures is perceived before the material itself is identified.

4. The following types of change were identified in the reproductions of perceived material: (1) Simplification, (2) Complication, (3) Completion, (4) Transposition and (5) Increased symmetry by means of: altered relations between parts, omission of asymmetrical parts, bilateral symmetry and improved grouping.

5. All of the changes mentioned under 4 above, occur also in memory reproductions.

6. 92% of the observers emphasized one or more parts of their reproductions at the expense of other parts.

7. The results of this experiment are harmonious with the hypothesis that all behavior follows the same principles.

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