

ON THE ANALYSIS OF THE MEMORY CONSCIOUSNESS: A STUDY IN THE MENTAL IMAGERY AND MEMORY OF MEANINGLESS VISUAL FORMS.

BY F. KUHLMANN,

Assistant in Psychology, Clark University.

TABLE OF CONTENTS.

- A. The problem and the experiment.
- B. Analysis of the results.
 - 1. The subjects' methods of learning the material.
 - 2. General analysis of the nature of the imagery and of the process of recall.
 - a. The visual imagery.
 - b. Uses associations and verbal descriptions have in common.
 - c. The characteristics of associations.
 - d. The characteristics of verbal descriptions.
 - e. Motor impulses.
 - f. Relation of factors when recall is uncertain.
 - 3. Dependency upon the nature of the form.
 - a. The altered familiar form.
 - b. The continuous irregular curve.
 - c. The several-part form of simple straight or curved lines.
 - 4. Dependency on repetition of recall and the lapse of time.
 - a. First stage.
 - b. Second stage.
 - c. Third stage.
 - 5. The errors made.
 - a. Their relation to the subjects' attitude.
 - b. Their permanency.
 - c. Their causes.
- C. Discussion.
- D. Summary.

A. THE PROBLEM AND THE EXPERIMENT.

The general purpose of this study has been to contribute something to the analysis of the memory consciousness. Its more special efforts, however, have taken two more definite directions. (1) To determine the nature of the imagery in the recall of a given material. (2) To determine the nature of memory errors and the causes that produce them. Its general

aim, therefore, differs from practically all previous memory studies in that no attempt was made to study the quantitative aspect of memory, the question as to how much can be remembered, and the conditions upon which that amount depends. At the same time no claim can be made for entire originality in either its purpose or in its methods. The need of the investigation of both these problems had been urged already by Kennedy in his review of the methods and results of experimental studies of memory.¹ Since his writing, one phase of the former problem has been definitely attacked by Angell and Harwood,² Bentley,³ Whipple,⁴ and Schumann.⁵ Perhaps some of the earlier studies and discussions on the nature of the recognitive elements in the memory consciousness should also be mentioned in this connection. All of these studies, however, were limited to the *recognitive* consciousness, with the interest centralized further on the part the image of the first stimulus plays in the recognition of the second. Angell and Harwood's results were mostly objective. From the difference in the number of right and wrong judgments on the pitch of the second clang, given with and without distraction between the first and second clangs, they infer as to the possible influence a memory image of the first clang could have had on the judgment of the pitch of the second. Schumann's study is more of the nature of a general argument in which introspective observations are not quoted with much detail. To my knowledge, Bentley, and Whipple are the only authors, so far, who have seriously attempted to study the problem introspectively and who have at the same time adequately recognized the need of applying this method rigidly to the more general problem of the analysis of the memory consciousness. The second problem stated, the causes that produce memory errors, has not been directly attacked in any extended study.

¹ 'On the Experimental Investigation of Memory,' *PSYCH. REV.*, 1898.

² 'Experiments on Discrimination of Clangs for Different Intervals of Time,' *Am. Journ. Psych.*, 1899 and 1900.

³ 'The Memory Image and its Qualitative Fidelity,' *Am. Journ. Psych.*, 1899.

⁴ 'An Analytic Study of the Memory Image and the Process of Judgment in the Discrimination of Clangs and Tones,' *Am. Journ. Psych.*, 1901 and 1902.

⁵ 'Beiträge zur Analyse der Gesichtswahrnehmungen. Dritte Abhandlung. Der Successivvergleich.' *Zeitschr. f. Psychol. u. Physiol. d. Sin.*, Bd. 30, 1902.

Considerable recent work has appeared on its quantitative aspect, the degree of memory error and some of the objective conditions under which it occurs. This is the central interest of the studies by Stern and his co-workers to whose results the *Beiträge zur Psychologie der Aussage*, the second volume of which is now current, is devoted. The objective results of the quantitative studies on how much can be remembered have incidentally thrown some light on the analysis of the memory consciousness. In quite the same way the studies by Stern and others throw some light on the causes of memory error.

The present study is most closely related to those of Bentley and Whipple, having in common with them, in the first place, the introspective method of study. The first problem stated above differs from theirs in being that of the analysis of the memory consciousness in the recall of a stimulus, instead of that of the memory consciousness in the recognition of a stimulus given a second time. The same stimulus was never repeated. A group of meaningless visual forms, five to nine in a group, was presented to the subject for ten minutes, and once only. Immediately afterwards, and again after a number of different intervals of from two to ninety days the subject was requested to recall the forms, giving as detailed an introspective account as possible of the nature of the imagery, the process of recall and recognition, etc. He was also requested each time to draw the forms thus from memory as accurately as he could. The forms were not equally meaningless, but were so constructed as to allow of a classification into three classes, viz., the altered familiar geometrical form, the continuous irregular curve, being the most meaningless, and the several-part form of simple straight and curved lines. With this procedure the results are of two kinds. The introspective notes give the direct evidence on the first problem, and are supplemented only a little by the objective drawings. The drawings constitute the main results on the second problem, and, from the nature of the problem, can furnish only indirect evidence. The subject not knowing the errors he made in recall could have nothing to say as to their causes. These must be inferred from the data at hand. But the introspective results supplement the drawings to such a de-

gree as to make the inferences perfectly evident in most cases.

B. ANALYSIS OF THE RESULTS.

1. *The Subjects' Methods of Learning the Material.* — Before considering the nature of the imagery in recall it will be well to take account first of the subjects' methods of learning the material. This will throw considerable light upon the later results concerning the nature of the imagery. By alternately trying to learn and then trying to recall the forms during the ten minutes in which a group was presented the subject at once found that the forms were not equally difficult, and much more time was then put on learning the hard ones. The methods employed in impressing the various characteristics of the forms on the mind may be classed into direct methods, and certain aids to these that were used. Under the direct come then, first, merely looking at the forms and noting their details visually, and second, motor processes of the eyes following out the forms and also of the hand tracing them. To these the aids were associations made with individual forms or their parts and verbal descriptions. The direct methods need no further consideration. The use of the aids may be further described. In every case the subject consciously sought for associations, and the question, 'What is this form like?' or its equivalent, was probably always present in the subject's mind. They were sought for as a means of fixing the memory of the form as a whole. This search ended, in the different instances, in a variety of results. The outcome might be successful in an actual association made. Secondly, an actual association might fail while yet the form attained a familiarity that it did not at first possess. In these instances the form would be regarded as something familiar and known; it would 'look like something they knew, but they could not tell what.' Thirdly, in some cases the form was broken up into parts which were learned and recalled in a definite order. These parts had an evident definite individuality which made them parts and thus, it seems, must have had some sort of meaning for the subjects. But it was not so regarded by them. They denied all associations and familiarity in these cases. Fourthly, the form might, of course,

remain entirely meaningless and unanalyzed into parts. The effect of an association made or of an associated familiarity was always that of putting the subject more at ease with reference to the form in question; it made the form easy, and with this much accomplished he would leave it, feeling satisfied that he could recall it when wanted. The verbal descriptions were made mainly for the purpose of fixing minor details of the forms. They were used for the alterations in the familiar geometrical forms, for the difference between the actual form and its association, and sometimes for the whole of a form that remained entirely meaningless. In the last case the description was that of a general characteristic with the same function as that of an association with the form as a whole. The minor details thus fixed in memory by description were further, relations, positions, proportions and sizes of parts, the angle a part made with another, the position of a meeting or crossing point and of endings of lines, the nature of a particular curve, length of lines, etc. No particular attention was as a rule given to sizes. When sizes were specially attended to the total amount and proportion of the page the forms took up might be noted, and to remember the particular size of each form that of one might be fixed and the relative sizes of the others noted. For this descriptive aids were usually used. Positions were fixed in memory by imagining the forms arranged on certain lines. Such lines were made use of in every case. They were so drawn through the forms as to make familiar forms themselves, and were dealt with in the same way as the forms they located.

2. *General Analysis of the Nature of the Imagery and of the Process of Recall.*—In considering the results of this section it will be helpful to keep in mind the fact that in order to draw the form again just as it had been seen in the original the immediate thing, the only thing really necessary was a correct visual image of the form. All the rest could come in only as a means of getting that visual image, and of recognizing it as the correct one. I shall attempt first a general analysis, disregarding for the present two large factors that were found to influence the nature of the imagery, viz., the nature of the form to be recalled and the time elapsed since the last. In this I shall

consider in order the visual imagery, the associations, the verbal descriptions and the motor impulses, and describe their nature and relations when a definite recall is the result.

(a) *The Visual Imagery.*— After the first sitting the subject never imaged the forms in the color of the original. In most cases he was quite unaware of the fact that the originals had been in white on black. Generally they were described as colorless when questioned on this point, or that the color in the image had never been noted. Undoubtedly this was due to the fact that no demand was made on the subject to remember colors. In some cases the subject visualized the page in proper size and form and the different forms would then be visually located on it. But quite as often perhaps the group as a whole was described as being visualized 'off in space,' or 'off at reading distance,' with no particular consciousness of the relations of forms to the page. Whatever the nature of the visual was in this respect probably depended mostly on whether or not the subject specially related one or more of the forms to the edges or other portion of the page as a means of remembering its relative or absolute position. Some sort of a visual representation of its position was the most frequent immediate antecedent to the visual image. In those cases in which the recall took place with the aid of an associated name or equivalent, the association generally followed the idea of the position of the form with which it was connected. Thus the subject nearly always stated that he knew where the form belonged before he had any further clue to its recall, and only several instances out of about a thousand are recorded where the form was recalled without a memory of its position preceding. With this much given, several grades of spontaneity of the visual image of the form itself might be described. Beginning with the most spontaneous are the cases in which the visual of the whole form comes out in a flash as soon as the recall is attempted, and in such completeness of detail as to seem absolutely perfect to the subject at once. Next in spontaneity are the images that show a distinct course of development. According to the nature of the form, it may come up in parts with time intervals between the visual recall of the different parts, or

it may develop gradually and evenly from one end to the other. A third class are those in which there is a considerable interval between the visual image of its general position and that of the form proper. The subject knows where the form belongs, but there follows some time before he gets a complete visual image of it. That interval may be entirely blank as far as any clue to recall goes, or it may be filled with one or more of such aids, visual, or in other terms. Recall with the presence of such an interval was the most common form. A fourth class was frequently noted. In these the attitude with which the subject approached the form was also characteristic. When the subject felt assured at once that he would have no trouble at all in recalling the form, he would not stop to get a complete visual image of it before he began to draw. The image would then develop part by part or in a continuous manner as he drew it, running a little ahead of the drawing. The character of the visual image varied also with reference to the ways in which the cognitive consciousness entered. The memory sanction might come in at once with a ready and complete appearance of the visual image. Or, the image might develop in wrong directions, more or less similar, that would be at once recognized as wrong. Sometimes the subject would state that he purposely tried on a number of different images to see which seemed most correct. Closely related cases were those in which the form was drawn from a tentative image and its correctness or wrongness recognized only after the drawing. This was a very common procedure throughout, and occurred especially with difficult forms and in the latter recalls. The subject might fail to decide whether a form as visualized was correct until he could actually see it on paper, when recognition might be quite prompt and decisive.

(b) *Uses Associations and Verbal Descriptions have in Common.* — The associations and verbal descriptions that were made have several things in common which may be noted before considering them separately. In the first place, both were used as aids to the recall of the visual image. When the direct recall of the visual failed the recall of an association or verbal description made at once sufficed to produce the visual image sought

for. Secondly, associations and verbal descriptions might come in after the visual had already appeared. In these cases they might reinforce the recognitive sanction of the visual image. They would come in to verify the visual, and the subject would then feel doubly assured of its correctness. Thirdly, either or both might follow the visual image without adding anything to the recall or affecting the recognitive state. They would then be regarded by the subject as a useless addition to the total process which might have once served its purpose but was now of no further value. Finally, both might be so very closely bound up with the visual, and be of so incipient a character as to make it impossible to decide certain aspects of their relations from introspection. The statement that the subject does not know whether the visual preceded or followed association or verbal description, that he does not know whether the latter were present at all or not in recall, or what use was made of them if they were present, occurs very frequently in the notes. In harmony with this is the very common observation that they were much in the background of consciousness, with the visual as the prominent and main process. This does not mean, however, that there were not plenty of instances in which these relations and the use made of the associations and verbal descriptions were perfectly clear to the subject. We may consider the associations and the verbal descriptions separately now very briefly.

(c) *The Characteristics of Associations.* — Several forms of associations and grades of closeness of connection with the visual image of the form can be made out. The association might be in the form of a visual image of the associated thing. There was then a real duality of visual imagery, and the name of the associated thing might not come in at all. But more usually the connection was closer than this. There would not be two visual images, that of the associated thing serving as a cue to the recall of the actual form and as a pattern to model it by, but the associated thing would be read into the form which was then usually named. Thirdly, the connection might be remote. The form might be named with the feeling that there was but little justification for the name. The name was then usually

the most prominent thing in the association. Fourthly, an emotional reaction giving meaning and familiarity to the form was sometimes present when the subject denied the existence of an association of any sort. While the association proper, visual image or verbal, had always the effect of adding this emotional complex, the latter might exist alone. It was quite common, too, for that feeling to precede any trace of a visual image of the form. In such cases the subject would describe his experience as that of feeling that he knew the form, of feeling sure that he would recall it in a moment, while yet he failed to do so. There was a different atmosphere surrounding the different forms that gave each more or less an individuality of its own, which caused the subject to approach the recall of the forms with different attitudes. While this was not marked enough in many, perhaps in most of the cases to receive special mention by the subject it seems very feasible that this emotional complex played a large rôle in the actual recall of the forms. But its analysis or even the determination of what part it played in recall was beyond the methods of the present study, and no special efforts were made in that direction. Whatever the form in which associated processes appeared, their general use as means to recall was to serve as cues to the recall of the visual image of the form as a whole, and in this respect, whether in terms of visual or verbal imagery, differed from verbal descriptions as a class. Considering only those cases in which they were thus means to recall, the associations aided in bringing up a general, often indefinite visual image of the form as a whole, or of the parts to which they were attached. As the subject often stated, they prevented the form from being forgotten altogether. They did little further towards filling in the details. These had to be recalled for the most part by other methods. The degree in which this was the case depended, of course, on how closely the actual form resembled the thing associated with or read into it.

(d) *The Characteristics of Verbal Descriptions.* — The part played by verbal descriptions in the recall of the forms can be inferred largely from what was noted above as to how they were used in learning the material. They were used for the forms

and parts which the subject found difficult to learn by merely looking at them. In a very rough way they entered the later recalls in the ways they had entered in learning the forms in the first place. The difficult parts were as a rule not recalled directly in terms of the visual, but the visual was built up through a recall of the verbal descriptions. Unlike the associations, however, they were rarely used for the recall of the visual of the form as a whole. They applied to the details after a general visual outline or pattern was already present; an outline that the subject at once regarded as only an outline in need of corrections and completion. They played their part further in getting the visual corrections for the associations made, so far as the latter varied from the actual form. And again with the forms that were more or less difficult throughout so that hardly any visual image of its general outline preceded, the recall of verbal description might come in almost at every point in the form. Special mention should be made here again of the very incipient character of the verbal descriptions in which they so often appeared. Apparently there was a very strong tendency for all but one of the subjects to describe incipiently the characteristics of a form in a visual image as he noted them. To attend to such characteristics meant largely to thus describe them.

(c) *Motor Impulses.*—It was observed that the development of the visual image might be gradual and continuous from the beginning to the end of a form. This carried with it a strong tendency to a corresponding eye-movement. As the image developed the eyes incipiently followed its progress. In some rarer instances this tendency to eye-movement assumed a greater independence of the visual image. In these the subject described himself as 'feeling' that the form extended in a certain direction, or that the eyes moved back and forth several times from one point to another with the expectation that the visual image would appear accordingly without it doing so at once. About the same is to be said of tendencies to hand movements, the movements of writing or of drawing. These were less frequent but with one subject seemed to be more prominent than the eye-movements when they were present at all. About

the part these motor impulses played in the recall of the visual very little can be said. There were not very many instances in which the subject stated that they preceded the visual. Their simultaneous appearance with the visual was the rule. The inference might be, therefore, that they were, so far, not aids to recall. However, the observation was made a few times that they not only preceded the visual but were the means of its recall.

(f) *Relation of Factors when Recall is Uncertain.*—There remains to be considered some of the ways in which these different factors in recall are related when the recall is uncertain. Recall might be uncertain because of a rivalry, when some sort of memory sanction went with each of two or more factors that conflicted. Or, it might be uncertain in the absence of such rivalry, from other causes. To the latter naturally belong by far the larger number of cases of uncertain recall. There are, of course, many instances in which the subject has tried on all the methods of recall, has brought in all the aids without complete success. The last resort in these instances is generally visual recognition. The form is actually drawn from a tentative image to see how it looks, and then re-drawn a number of times to make it look more satisfactory. The final outcome of such a procedure was often the statement of the subject that the drawing looked wrong but that he did not know where or how to change it so as to improve it. A special instance of this kind that was quite common were cases in which a description on account of its ambiguity was itself inadequate for the recall, and recognition remained indifferent to the several different visual images that might be constructed. A real conflict or rivalry between the different factors or between different imagery of the same class occurred in several different ways. In these a distinct memory sanction went with more than one construction of the form and resulted in uncertainty as to which was correct. This might occur between two visual images. A form or part might look right when taken by itself, but when considered in relation to some other form or part it might appear wrong as imaged or drawn, and seem right some other way. More frequent were the conflicts between the visual image of a

thing associated with a form and that of the actual form. Here of course, no separate and definite visual image of the actual form would be present, but rather the subject would feel, recognize, that the form as he imaged and drew it was too much like the associated thing, while yet there was something about the former that tended to make him accept it as correct. Still clearer cases of real conflict were those in which a visual image would come up and by itself be regarded as quite correct, while at the same time certain verbal descriptions recalled would contradict the visual image. Quite a number of these cases occurred and in many of them the subject in the end gave up the recall with the statement that he did not know whether visual image or verbal description was correct.

3. *Dependency upon the Nature of the Form.* — We may turn now to a special consideration of the factors already named that influenced the nature of the imagery. The forms as given could be roughly classed into three groups. (a) The familiar form with some alteration attached. (b) The continuous irregular curve. (c) The several-part form of simple straight and curved lines.

(a) *The Altered Familiar Form.* — The familiarity of a form depends of course on the degree of the subject's success in reading meaning into it. First in this class were the altered geometrical forms and I shall limit the description to them. The subjects, without exception, regarded these as easy forms. In learning the group they were at once recognized and picked out as such, and but little time was spent on them. The exact nature of the basis for this faith that they could be easily remembered seemed peculiarly hard to determine. It was not the presence of the association, the name of the form, nor a general visual image of an associated thing. These were in by far the majority of cases quite in the background or entirely absent, and did not affect for this reason the feeling of the subject towards these forms. It was rather a distinct characteristic emotional attitude together perhaps with certain characteristics of the visual imagery itself. No further analysis was made of this. In the recall of the form this attitude was a part of the recall. The subject approached it with ease, and certainty that there would

be no difficulty. With the general clue to recall given, described before as some sort of visual representation of its position on the page, the subject would at once know its general character and that the form could be recalled at will. The visual image would be described as easy and very spontaneous. It would come up in a flash and stand out as a whole in clearness, in a definite, unambiguous, unwavering character. Or, it would come up part by part or develop continuously as it was needed while drawing the form. In the latter the subject was so certain of its recall that he seemed to deem it not worth while to go to the trouble of first getting a complete visual image of it before beginning to draw it. Cases of this sort were very frequent with this class of forms. Whatever the character of the direct visual image, the nature of the recognitive sanction was the same. It was immediate and decisive. There was no need of resorting to the recognitive method, drawing the form and then re-drawing until it looked right. All these characteristics, however, hold true only of the main parts of the form, of it so far as it corresponded to the familiar geometrical form that was read into it. The recall of the alterations was quite different. These constituted the details, and in learning and in recalling them verbal descriptions entered in the same ways as they did for any other kind of form.

(b) *The Continuous Irregular Curve.*—In most of its essential characteristics the imagery and process of recall for the form that consisted of a continuous irregular curve was strikingly different from that just described. These forms came nearest to remaining entirely meaningless. They were at once recognized as hard to learn, and received special attention. With the general impression of meaninglessness went a special effort to read meaning into them, which was found difficult. When an association with the form as a whole was made it usually needed so much revision as to be of little service in recalling anything but the roughest outline of the actual form, and for this it was hardly ever needed after the extra time spent in trying to fix it visually. Characteristic in learning them was the abundant use of verbal descriptions. The fixing of the visual had to be helped out at every point by description. In the

recall later the attitude present in learning reappeared. They were approached with the feeling that there would be difficulty in recalling them accurately. The next thing then in the recall was visual imagery, direct, perhaps quite as often as some association or general description. The visual might be an indefinite, wavering image of the form as a whole. Or, it might start at a certain point in the form and then slowly develop through for the rest, with many hitches, ambiguous, and uncertain places. When it came up as a whole certain loops or large turns in the curve would stand out roughly more prominently than the rest, with only a vague consciousness of connections or other parts, and of their general position in the form relative to the parts that stood out more clearly. This much might come up quite readily. The form as a whole might be fairly easy to recall. The difficulties came in attempting to fill out the rest. The general character of the procedure in the other form of development of the visual image, when it developed slowly from one end to the other, was not so much different in its essential nature. In this case, too, the image would be made up of prominent, more or less clear, and indefinite, unstable parts. In both instances the recall of verbal descriptions came in at the points where there was hesitancy and difficulty in the visual imagery. It did not, however, enter so abundantly as might have been expected from its extensive use in learning the forms, although it was still much more frequent than in the recall of the other forms. Strikingly characteristic was the recognitive method of recall, one that in general was applied when all other aids failed.

(c) *The Several-part Form of Simple Straight or Curved Lines.* — In its more important aspects the recall of these is of an intermediate nature to that of the two classes of forms just described. It is a form made up of familiar, known parts, and to that extent it is easy. But the parts are put together in an unusual way, and in this respect the form is hard. The first thing characteristic about their recall was the frequent use of associations for the form as a whole. In the first class of forms, the familiar geometrical, the visual alone was so self-sufficient in the recall that the associations were rarely made use of. In

the second class the form was so irregular and unusual as to make it very difficult to read any meaning into it. In this third class the association with the form as a whole was both possible and necessary. With these they came in more than with any other as real means to the recall of the form as a whole. In accordance also with what we might now expect, the recall of the parts was easy. They needed no descriptive or other aids to decide their exact nature. The aids to recall were used in getting the relations between these parts, the ways in which they were put together. Thus the subject would seldom fail in recalling all the parts with certainty, but would often be very uncertain about their relations. Here the verbal descriptions, the special associations and the purely recognitive method were all employed because they were found necessary. There was more occasion for the description to be ambiguous. The subject would often recall in descriptive terms that a form was made up of certain angles, curves, straight lines without any further recall of their relations. The visual imagery in the recall had only one point that was characteristic of this class. It was more distinctly broken up into parts than was true of the other forms, as a rule.

4. *Dependency upon Repetition of Recall and the Lapse of Time.* — The time intervals between successive recalls of a group were short for the first few, and very much longer for last recalls. The differences that were found to go with these conditions were great enough to be distinguishable at least into three grades or classes, and I shall attempt to describe them in this way. The second stage will show the influence of repetition of recall after short time intervals. The third will show the influence of long time elapsed during which the forms were not thought of at all. It is not to be understood, of course, that a certain kind of recall always went with a certain time interval, nor even that the memory for each form passed definitely through the three stages to be described. All that the results show is a constant tendency in the same direction. Whenever changes occurred, and there did in most cases, they were of the same nature. But in the individual cases the recall of some forms could never be classed under the first, while that of others never reached the third stage.

(a) *First Stage.* — The cases that fall under this class are limited almost entirely to the first recall of a group. Its main characteristic is the rapid dropping out of the verbal descriptions used to fix the details that had been specially noted. During the ten minutes allowed for learning the group many such descriptions would be made to fix the visual. Half an hour or so later in the first recall it was a very common observation on the part of the subject to note that he had used many descriptions in the learning which now were not made use of in the recall. He recalled the forms directly in the visual, with the recall of the descriptions following, or with merely the recall that some descriptions had been used but were already forgotten. This was much less true of the associations that were made with the forms as a whole. Such an association was but very rarely forgotten during the first sitting. It was also more apt to be really used as a means to recall at this time than it ever was later. The visual imagery was of an average spontaneity. Much of it came up only through the recall of associations and verbal descriptions. With this recall went only about an average degree of certainty on the part of the subject, perhaps even less.

(b) *Second Stage.* — The main characteristic of the second stage is an increased spontaneity of the visual imagery and the relative absence of associations and descriptions as aids to recall. The forms are recalled for the most part directly in terms of visual images, and the corrections and revisions to be made in the first image take place without descriptive or other aids. Further characteristics of greater spontaneity of the visual image are its more ready appearance, with less pauses, and less hesitations as to correctness. There is an immediate and greater certainty and satisfaction. The associations and descriptions that do come in are more apt to follow than to precede the visual, and the greatest use that they can have is to strengthen the recognitive sanction that goes with the visual image. This they may do, but the cases in which they are regarded by the subject as entirely useless in the recall are most frequent in this stage.

(c) *Third Stage.* — The last recalls show the marks of a

partial loss of memory of the forms. The first of these is a general inefficiency of the visual imagery, and a lack of spontaneity. The recall is more likely than before to be preceded by an interval in which neither a visual image or any aid is recalled. When a part of the visual arises it proceeds more slowly in its development, is more apt to be broken up into parts with time intervals between the recall of the different parts, and with decidedly more wavering and hesitation as to the correctness of what comes up. Several slightly different images are apt to arise, having attached to them hardly any recognitive sanction. The recognitive method is more frequently resorted to. The subject's attitude towards the form as he finally draws it is also characteristic. It is likely to be either that of indifference, or of uncertainty. In the first stage he may be uncertain, but rarely indifferent. In the second he is generally certain. This indifference means that a visual image of a form comes up perhaps with relative ease and absence of rivals without any definite or strong memory sanction going with it. There is nothing to suggest that it is wrong, and in connection with the other characteristics its correctness is taken as a sort of matter of course. It is of the nature of the cognitive instead of the recognitive state. With the difficulty to recall the form at once in purely visual terms goes the attempt to find aids to the recall. The associations for the form as a whole are likely to come in again as a real aid. Aids are found more necessary for the recall of the details, but here the subject finds that he has forgotten much of the verbal descriptions once used. He may remember at what points they were used before but have forgotten what they were. This is quite common. The recall of false descriptions is also characteristic of this stage. Often the subject stated that he recalled a certain description when that description did not fit the original form as presented to him at all. These are probably mostly instances in which he had on previous occasions descriptively noted certain characteristics of his visual images, cases in which these images were wrong. In some instances they are descriptions of previous drawings that are wrong. Finally, these last recalls are characterized by a greater frequency of rivalry between the different

factors in recall; rivalry between the different visual images, and between a visual image and a verbal description.

5. *The Errors Made.* (a) *Their Relation to the Subject's Attitude.* — The errors made by the subjects in the drawings of the forms should be considered in close relation to the foregoing description. That will make many of them already intelligible, and a further consideration of their causes will throw additional light on the nature and analysis of the memory consciousness. It would be natural to suppose that the errors would be most frequent at the points where the subject found the most and greatest difficulties in learning the forms, and again in the recall where he was not certain of the correctness of his results. But, as a matter of fact, there are so many important exceptions to this that neither of these generalizations would be valid. It is true that errors occurred most for the minor details, and these were the things for which the visual imagery alone was found most inadequate, for which various descriptive aids had to be brought in. But this was not true of all details. And again, it was often in the forms that the subject called easy that he made the most and greatest errors. The frequency of the errors made, therefore, has no regular relation to the subjects' feelings of the ease or difficulty in learning the form. At certain points the subject was especially aware that he was probably making errors, and in a few instances he even noted a possible cause of error. Of the details of the form made up mostly of one continuous irregular curve the subject was as a rule more or less uncertain. In this his memory judgment was usually correct. Errors were frequent here. But errors were perhaps quite as frequent in some other kinds of forms in the recall of which the subject was entirely unaware that any could possibly have occurred. There was, therefore, no regular relation, either, between the frequency of errors and the subjects' degree of certainty and the correctness of his recall.

(b) *Their Permanency.* — A cursory examination of the results suggests a two-fold classification of the errors. First, on the basis of the permanency of the error after it once appeared, and of how it changed when it did not remain constant in the successive drawings. . Second, on the basis of the causal

factors that are evidently at work in producing them. Briefly followed out, this scheme will make their description complete. Something may also be suggested at the same time towards accounting for their permanency or variability. By far the majority of the errors that occurred were present in the first drawings, and remained more or less constant throughout the successive recalls. This was unquestionably a consequence of the conditions of the experiment. The subject had only ten minutes to look at the original forms. During the first sitting and again in each following one he had occasion to look at and consider his own drawing of it for about an hour. Thus the later recalls were perhaps recalls of the previous drawings as much as of the originals. All the errors, therefore, that appeared in the first drawings would be permanently fixed and regarded as part of the original ever after. A much smaller number did not remain permanent. In some of these the changes took place in a constant direction. The error would remain the same in character, but increase in degree in the successive recalls. In others the error changed in character, or at least did not simply increase in the same direction. In cases of the latter class the explanation of their behavior is by no means entirely clear. It can for the most part not be safely inferred either from the drawings or from the introspective notes. The notes are not always complete enough to include full reasons why a particular part in question was drawn just that way. When the changes in the errors were all in the same direction the causes were in nearly every case quite readily determined. These need not be taken up separately at this point. In the following classification and description of the errors according to their causes, the latter are taken up in the order of frequency with which they produce errors.

(c) *The Errors According to Their Causes.*—It might be supposed that an inference as to the cause of any memory error would necessarily be very unsafe. Our memory consciousness is so very complex and the number of different possible causes in any given instance so very great that we should hesitate to say anything about what the real cause was in any given case. On merely *a priori* grounds this attitude would

be quite the correct one. But the nature of the results in this case is such as to dispel this difficulty. At least those causes that will be enumerated are perfectly clear.

(1') *Ambiguous Verbal Description*: A small number of errors resulted from ambiguous description. The subject might, for instance, note that a form was made up of certain familiar parts, curves, straight lines, angles, etc. This in itself would make the form seem easy. But when he came to the recall of such a form later he would often find that the relation of the parts had not been sufficiently observed. He would recall the names of the parts and their exact visual imagery quite readily. But he could not put these parts together so as to be recognized as correct either from the visual imagery of the separate parts or from the descriptive names. Again, a form might be described as large or small in relation to some other, or a position might be described ambiguously in relation to some standard, as out of the vertical, or horizontal, or not quite parallel or perpendicular, as far or near; or the nature of a part be described as curved or angular. These descriptions were indeed aids to recall, but since the recall through them could never be more accurate than the descriptions they sometimes left room for a wide range of error.

(2') *The Influence of Associations*: The influence of an association as a cause of error has already been suggested. This was quite common in the cases of an association with the form as a whole, in fact, it was the rule when a definite use was made of the association in recall. That influence consisted simply in changing the form as recalled so as to resemble the associated thing more than the original form as presented did. The change tended to take place gradually. Apparently the subject forgot gradually more and more the points of difference between the associated thing and the real form, so that when in the later recalls the association was still made use of the visual image of the associated thing took the place of that of the real form without any suggestion of error to the subject. Out of quite a list of illustrations of this influence there were very few clear instances in which the subject was suspicious of it. In these that suspicion consisted merely of a vague feeling that

surely the real form was not so much like the associated thing as drawn, while at the same time when the drawing was considered by itself with no special attention to its great similarity to the associated thing it seemed quite correct.

(3') *The Influence of Certain Standards in Forms, Positions and Relations*: A third source of error is quite similar to the influence of associations, but appeared in a variety of ways, or consisted perhaps of slightly different factors. These may be enumerated separately without a special consideration taken of the characteristics they have in common, for these will be evident enough. First among them to be mentioned are the standard, simple geometrical forms. In the cases where the form or a part as presented very much resembled one of these the small differences tended to drop out in the later recalls. A special instance of this that was very frequent was the part of a form that consisted of a slightly irregular curve. The irregularities dropped out making the part a smooth even curve. This might be the effect of an association were there not so many cases of this sort in which the subject denied that the idea of the geometrical form had at all occurred to him, and were there not so many quite similar cases in which no such association was possible. These similar cases are instances, first, in which errors in position of a form or part occurred. A line that was not quite vertical or not quite horizontal in the original form tended to be recalled as just vertical or just horizontal. Secondly, the parts of a form tended strongly to take on certain standard relations to each other. Parts that were not quite parallel or perpendicular to each other tended to be drawn just parallel or just perpendicular. Thirdly, parts that were not quite equal in length tended to be drawn equal. Fourthly, parts tended to be arranged symmetrically where no exact symmetry existed in the original, in some instances changing the nature of the parts considerably at the same time. Crossing points were placed at the middle when in the originals they were a little away from the middle, or were placed at the ends when in the original they were not quite at the ends.

C. DISCUSSION.¹

This study was made in the spirit of Titchener's recent reassertion that the best way to make a mental analysis is to appeal to consciousness directly, rather than to use the psychophysical methods in which the analysis is an inference from objective data instead of the introspective.²

Memory studies in which the former methods have been used are numerous. These have clearly established a number of things, first among them in importance for our present consideration being the fact that very much less can be remembered of a material that is very simple in its nature than of a material that is more complex. The inference also from this that the amount remembered depends in the first place on the number and closeness of associative connections with the material and between the different elements of it is undoubtedly largely correct. But it is wrong in so far as it overlooks the extent of the influence of the other factor which introspective observation brings out. The few results of the present study show clearly enough that associative connections are a great aid to recall, if any further proof of this were needed, but they also show that the matter of inherent spontaneity of the imagery directly concerned in the given material is an aspect of recall equal if not of greater importance than are associations, and that spontaneity is not necessarily dependent upon associative connections if introspective observation is to be at all relied upon. The familiar geometrical forms were the easiest to recall, but also those for which the subject was most apt to deny the use or presence of any associations whatsoever. Again, the spontaneity of the imagery in the three stages described varied independently of the frequency of the use of associations. The second stage, *e. g.*, showed the greatest spontaneity of the visual imagery, but the least use of associations. To what extent spontaneity is to be attributed to what psychologists have usually called the influence of repetition needs no discussion

¹ For a summary of results see pp. 343 f., if this is desired, before considering their discussion.

² Titchener: 'The Problems of Experimental Psychology,' *Am. Journ. of Psych.*, 1905.

here. The interest in this kind of fact lies not in its cause, but in what evidence it gives in favor of one of the two opposing theories of recall, the theories, viz., that all recall is mediated through some associative connection, and second, that recall is sometimes of a spontaneous origin, thus breaking the associative continuity of mental processes. In this connection it is to be borne in mind that the associations made use of in the recall of the forms in this experiment were not associative links between the different forms of the group. They were associations with one or the other particular form and were entirely foreign to the rest of the group. The only reason why they could come in at all was because they could be more easily recalled directly than the forms themselves with which they were associated. In other words, the imagery of the associations possessed a greater spontaneity than did that of the form itself. In all these cases we have instances in which the mind makes use of the fact of greater spontaneity of certain imagery to insure recall of the thing with which it is associated rather than depend on the law of contiguity for the recall of the other forms of the group. In the present study indeed the latter was found again and again entirely inadequate for the purpose of recall. Nearly all the characteristics of the recall were not such as pointed to associative connections mediating the results, but the ways in which the imagery came up indicated rather that it depended much more upon its own inherent nature and organization. To say, then, that a complex material is better remembered than a simple because of more associative connections becomes in the light of this consideration not more than a half truth. The complex material is at the same time the material that has been most frequently an object of consciousness. The fact that small differences in sense qualities, *e. g.*, can be remembered but for so short a time may be due more to less spontaneity than to less associative links on account of the simplicity of the material. The objective results of psychophysical methods have carried the analysis further by showing that more is remembered of a given material if the subject is allowed while learning it to (*a*) articulate the associated names, or is allowed (*b*) certain motor processes of hand movements at the same time while he is look-

ing at the material, or if (c) the material is presented jointly to more than one sense than when it is presented to one sense alone. This involves more than merely the increase of associative connections. The results of the present study are in harmony with all and they verify the first two. We have seen what part verbal description and associated names play in the recall of the material used, and also, to some extent, how motor processes come in. The objective methods of Stern and others have also already taught us much on the degree of normal memory illusion, and have indicated some of the external conditions on which that degree depends. My results do not give much on the *degree* of memory illusion. But they give at least equally important data; they show something of their nature, and very distinctly some of the causes that produce them, and, in my opinion, establish the validity and greater usefulness of the method for working out their whole psychology.

These are all the general points of any significance that the results of this study have in common with others in which introspective observation was not made use of. Let me turn now very briefly to their further interpretation. Limited as the results are to the mental imagery and memory of meaningless visual forms, they cannot go very far towards an analysis of the memory consciousness in general. Their significance should be judged only in the light of the much larger program for this general method of approach. If we had much more extensive results not only for visual material of different kinds, but the same also for all the other sense departments, we have reason to suppose that they would give us a far better understanding of this whole question than the results of objective methods ever could give. At the same time a few points of general significance that even this study has brought out may be considered here. The analysis has not merely shown the existence of certain associated processes in the recall of a material that is presented to one sense alone, but it has gone a considerable ways towards determining at just what points, in what ways these processes enter, and what their exact function in the memory consciousness is. In the present experiment the tendency is for the material to be recalled directly in terms of

imagery that belongs to the sense to which the material was presented. This is the simplest expression of mental economy. It indicates that, so far, nothing enters consciousness that does not serve directly the end desired. But the visual imagery was found so inadequate for its purpose that at many points associative aids had to be resorted to in order to reëstablish the visual in its full integrity. With the frequent repetition of the recall the visual attains a greater degree of spontaneity. This, taken in a large way, is a gradual process, during which the associative and other aids recede step by step. They first come in as aids to the recall, then only to reinforce the memory sanction that goes with the visual image that is already present, then cease to do even this while yet they enter, and finally drop out altogether. This gradual elimination of the aids to the recall is another expression of mental economy, which culminates at the point where the subject not even goes to the trouble of first getting a complete visual image of the form, but begins to draw at once from the first suggestion, letting the visual image develop as needed while drawing; or, if the few observations on this point are to be taken as indicative of the direction in which the truth lies, it culminates where the subject draws from a motor memory, where he denies the presence of anything that can be called a visual image.

This strong tendency for the mind to follow 'the line of least resistance' is reflected again in the character of most of the errors that are made. These can almost all be described by the one general characterization that an easier visual image that is more or less incorrect is substituted for the correct image of the actual form which would be more difficult. At least this description applies to all those errors that are not due to errors in the aids to recall, but are connected directly with the visual image. The visual image constantly tends to take the form of one that possesses the greater spontaneity. It tends to the visual image of the association that is made, an association whose only reason for existence in the first place, as was just noted, is the fact that it possesses a greater inherent spontaneity than does the exact visual image of the real form. It tends to certain standard positions and relations, such as the exact vertical, the horizon-

tal, the symmetrical position, in each case undoubtedly because these relations are more easily held in mind and recalled than the exact amount of variation from such a relation would be.¹

This brings us to a second matter of general significance which the results clearly indicate — the degree of resemblance between the inner organization of the memory imagery and the process of recall on the one hand and that of the perceptive experience on the other. There is still a tendency in psychology to accept the naïve conception of memory consciousness as weakened copy of original perception with a recognitive factor added. Perhaps there is no great need any more of combatting this conception. But it may be well to let such results as those of the present experiment remind us of the degree and ways in which such a view is a misconception. Compare on this point again the kind of consciousness, its content and organization, involved in learning the material with the kind of consciousness involved later in the act of recalling that material. Certainly the process of recall is not a weakened repetition of the process of learning. The total process of recall in the later instances was a quite different thing from the first recall immediately after the presentation of the material, and between these, for the different time intervals, were found many variations in that total process. Further, these variations had a wide range, not only for the different time intervals and the frequency of the recall, but were influenced also by the nature of the form. Nor can it be said with much more validity that the final result of the recall, the completed imagery that is used in drawing the form again from memory, is a weakened copy of original perception. In striking contradiction to this view is first the fact that in many instances no such completed image came in at all in drawing the form. Consider in this connection the differences in the nature of the visual image accordingly as the form was a very easy and familiar one, or, on the other extreme, was the very meaningless continuous irregular curve. Yet, on the side of

¹ This is in close harmony with Leuba's hypothesis, which Stratton also accepts and elaborates, that our memory tends to the more usual and common in our experience. Leuba, 'A New Instrument for Weber's Law, with Indications of a Law of Sense Memory,' *Am. Jour. of Psych.*, Vol. V., p. 370. Stratton, *Experimental Psychology and Culture*, New York, 1903. Ch. IX.-X.

mere perceptive experience there could be no great difference between the form that was easy and the form that was hard to learn and to remember. The characteristics of the continuous irregular curve were as easy to perceive as were those of the simple square or circle. With the same visual perceptive experience we find the visual memory image at times more or less adequate for the purpose of drawing the form again correctly, at other times we find it hopelessly inadequate. And again, the visual image might be regarded by the subject as 'good' while his drawing is quite inaccurate, and *vice versa*. Less intensity and vividness is among the least of the characteristics in which the memory imagery differed from its perceptive experience. Lastly, the function and importance of what is usually termed the 'recognitive factor' is not adequately described by calling it merely an added factor in the sense usually meant. It enters into the inner organization of the memory consciousness at every point in the recall, rejecting here and accepting there, thus determining the whole course of recall and the final product together, as well as being a mere reaction to that product when already present. Whatever the elements are in this emotional reaction, it is a reaction that enters before as well as after the image is completed. In addition to this there is another 'added factor' that is perhaps closely akin to the recognitive. This is what has been described as the characteristic attitude with which the subject approaches the recall of the difficult and the easy form. The emotional reaction that is characteristic of expected ease or difficulty of recall is often a very prominent factor after the first clue, such as the indefinite visual representative of its position, is given. Nor is the subject indifferent in this respect at any point in the recall. Every step is wrought with tinges of emotional reactions to what else is going on in consciousness, although this may often escape the subject's notice because of its nature it is difficult to analyze out and describe. The original perception of a form may be a very 'cold-blooded' affair while its recall from beginning to end is alive with a content that did not enter into the original perceptive experience. In a word, taking all these several matters into consideration, it must be observed that what we have called the total process of

recall is very largely not recall at all, and can never be described even half correctly by calling it reproduction. It is rather a construction, not a reconstruction, a construction of a certain result that is accepted in place of the original, and far from a reconstruction of a past perception.

D. SUMMARY.

In learning the forms the subject alternately noted their characteristics and then tried to recall them. This was a method of determining difficult points and to these special attention was then given. They consciously sought for associations for a form as a whole, and, less frequently, for certain distinct parts of a form. These associations served as aids to the recall of the form as a whole or of the parts in question. A second general aid for fixing, and for recalling the visual image of a form was verbal description. This was used for the most part at the points where special difficulties were found, for the minor details, and for necessary corrections in associations that were used.

In the recalls the direct visual imagery showed distinct grades of spontaneity, and differences in the order of its development. With the somewhat indefinite visual representation of a form's position given, its visual image might flash up at once as a whole, clear and distinct and without any alterations taking place. With these acceptance as to correctness was mostly immediate and complete. In other cases a certain interval, variously filled, might follow the first recall of its position before anything about the form would come up. The visual image of the form itself might develop slowly, in a fixed order from beginning to end, instead of all parts simultaneously. In this gradual development several similar images might come up one of which is finally kept as correct or nearest correct. With those not kept usually went a slight memory sanction, a recognition that the real form was something like this. Sometimes the subject guided his imagery purposely in this way as a means of accurate recall when there was some difficulty. Or, instead of this sort of gradual development, the image might simply stop at certain points, and after some hesitation proceed again

in a direction that was accepted as correct. For particularly easy forms the subject would be apt not to go to the trouble of first visualizing the form in all its details before drawing. The visual image would come up part by part, or in other ways as needed while drawing. For particularly difficult forms or parts the subject resorted to the recognition method. He would do the best that he could with his visual imagery, draw the form accordingly, and then decide from the looks of his drawing at what points it was wrong, and re-draw it until it looked as satisfactory as he could make it.

The uses made of associations and verbal descriptions have certain things in common. Either might be used as real aids to recall the visual; it would be recalled first, as a means of suggesting the visual. Or, either might be recalled after the visual image had already appeared. In this case it might strengthen the memory sanction as to the correctness of the visual, giving added assurance, or it might leave the recognitive state entirely unaffected, coming in as an entirely useless factor in the process of recall.

The association, as a rule, was connected with the form as a whole, and was a means of preventing it from being forgotten altogether. It might be in the form of a visual image of the associated thing, or consist merely of the name of the thing. Various degrees of closeness of connection existed.

Verbal descriptions were used for the most part for minor details, for the relations of parts, for the positions of crossing points and endings of lines, for corrections necessary in the associations made, etc., and sometimes for a general description of a form as a whole, approaching more in this case the nature of an association. They were quite apt to be of a very incipient character, so that the subject was not always certain whether they had come in at all, or what use had been made of them.

Certain motor impulses were sometimes described by the subject. These consisted of tendencies for the eyes or hand to move along the form as it appeared in the visual image, in the direction and order followed in the drawing. In a few instances these preceded the visual image and were regarded by the subject as real aids to recall.

Two large factors present influenced the character of the recall and the nature of the imagery. (1) The nature of the form. (2) The frequency of repetition of recall and the time elapsed. The recall of the altered familiar geometrical form the subject approached with a characteristic attitude, a feeling of ease and certainty that there would be no difficulty. The visual image came up readily, unwavering in character and was at once accepted as correct. Associations very rarely were needed as aids to recall, and as a rule remained much in the background of consciousness. Descriptive aids for the alterations in the actual form from the familiar geometrical were used here as in other forms to recall details. The forms consisting of a continuous irregular curve were the most difficult and their recall approached with an attitude the opposite in character to that in the preceding. Associations were specially sought for but difficult to find. Much verbal description was needed for the various details in the curve. In the recall a first very general and schematic visual image, which was at once regarded as such by the subject, might be quite easy and spontaneous. Special and great difficulties were then found in recalling the details, in which the recall of verbal description generally came in as an aid, and for which the resort to the recognitive method was frequent, with the final result often uncertain. Or, the visual for the form as a whole might develop in order from one end to the other, with the hesitations, resorts to aids, and uncertainties entering at the difficult points of details. The recall and nature of the imagery for the several part forms of simple straight or curved lines was in a way intermediate in character between the other two. In these the parts were familiar and easy, but their relations unfamiliar and difficult. Associations were found necessary and also possible. Their use as real aids for the recall of the form as a whole was frequent. The recall of the parts by themselves was relatively easy, but their exact relations difficult and aids often resorted to.

The influence of repetition of recall and of the time elapsed was great enough to make distinguishable at least three stages. The first is characterized by a rapid dropping out of verbal descriptions as aids to recall which had been used in the learn-

ing, while yet they come in as real aids more abundantly than at any other time. The more frequent use of associations, an average spontaneity of the visual imagery and degree of certainty are also characteristic of this stage. In the second stage the visual imagery shows the greatest spontaneity. It comes up readily at once, without associative or descriptive aids. The first image is more apt to be correct, and if not, the corrections are made directly in the visual. Immediate and a strong degree of certainty goes with the visual imagery. Associations and verbal descriptions come in after the visual images and without affecting the recognitive state oftener than at any other time. Marks of a partial loss of memory characterize the third stage. There is a general inefficiency and lack of spontaneity of the visual imagery. It develops slowly, with many hesitations and intervals during which neither visual or other aids arise, and in wrong directions with only a slight degree of recognition of their inaccuracy. Previous associations are sought for and enter again as aids to the recall of the form as a whole. The subject tries to recall verbal descriptions for the details, but finds that he has largely forgotten what they were. False description, and rivalry between the different factors are frequent. Resort to the recognitive method, drawing the form and determining corrections from the drawing, is found more necessary than ever before, and the subject is more often uncertain or indifferent to the final result.

The errors made in the successive drawings of the forms had no regular relation to the subjects' judgment of ease or difficulty of the form while they were learning it, nor to his certainty or uncertainty as to the correctness of his drawing. With reference to the permanency or course of development they fall into three classes. (*a*) By far the majority of the errors appeared in the first drawing of a group and remained constant in the later drawings. A smaller number did not remain permanent. (*b*) Some of these remained the same in character but increased in degree in a constant direction, generally indicating a definite cause of error at work. (*c*) Others changed in character, or at least not simply in degree in the same direction. The causes of these were not often evident.

With reference to their causes, the errors fall into three classes, though in the last possibly several slightly different factors are included. The definite objective results together with the detailed introspective notes generally left no doubt as to the interpretation as to the cause of the error. (*a*) Ambiguous verbal description when the visual alone was inadequate to correct recall often results in error. (*b*) The influence of an association made with the form as a whole or definite part tended to make the drawing more like the associated thing than the real form. (*c*) (1') Certain parts of a form approaching in character that of parts of certain familiar geometrical forms tended to be drawn more like the latter than they were even where the subject denied all traces of any association with the part in question. (2') With reference to position on the page, lines that were not quite vertical or horizontal tended to be made just vertical or horizontal. (3') Parts of a form that were not quite perpendicular or parallel to each other tended to be made just perpendicular or parallel. (4') Parts that were not quite equal in length tended to be made equal. (5') There was a tendency to arrange parts symmetrically.

In this study I am indebted to Professor E. C. Sanford for suggesting the general problem and for encouragement to take it up, and to Mr. W. F. Book, Dr. E. Conradi, Mr. A. L. Gesell, and Dr. L. M. Terman, Fellows in Clark University, for much patient and expert work as subjects.¹

BIBLIOGRAPHY.

- ANGELL and HARWOOD. 'Experiments on the Discrimination of Clangs for Different Intervals of Time.' *Am. Journ. of Psych.*, 1899.
 'Discrimination of Clangs for Different Intervals of Time.' *Am. Journ. of Psych.*, 1900.
 BENTLEY. 'The Memory Image and its Qualitative Fidelity.' *Am. Journ. of Psych.*, 1900.
 GAMBLE and CALKINS. 'Die reproduzierte Vorstellung beim Wiedererkennen und beim Vergleichen.' *Zeitschr. f. Psychol.*, 1903.

¹ The MS. of this article was received May 2, 1906.—ED.

- ‘Ueber die Bedeutung von Wortvorstellungen für die Untersuchung von Qualitäten sukzessiver Reize.’ *Zeitschr. f. Psychol.*, 1903.
- HENDERSON. ‘A Study of Memory for Connected Trains of Thought.’ *PSYCHOL. REV. Suppl.*, ’03.
- HÖFFDING. ‘Ueber Wiedererkennen, Association und psychische Activität.’ *Vierteljahrsschrift f. wissenschaft. Philos.*, 1890, pp. 27, 167 and 293.
- KENNEDY. ‘Experimental Investigation of Memory.’ *PSYCH. REV.*, 1898.
- LEUBA. ‘A New Instrument for Weber’s Law, with Indications of a Law of Sense Memory.’ *Am. Journ. of Psych.*, Vol. V.
- LEHMANN. ‘Kritische und Experimentelle Studien über das Wiedererkennen.’ *Philos. Studien.*, VII.
- MACDOUGALL. ‘Recognition and Recall.’ *Journ. Philos., Psych., and Sci. Meth.*, 1904.
- SCHUMANN. ‘Beiträge zur Analyse der Gesichtswahrnehmungen. Dritte Abhandlung. Der Successivvergleich.’ *Zeitschr. f. Psych.*, 1902.
- SLAUGHTER. ‘A Preliminary Study on the Behavior of Mental Images.’ *Am. Journ. of Psych.*, 1902.
- TITCHENER. ‘The Problems of Experimental Psychology.’ *Am. Journ. of Psych.*, 1905.
- WHIPPLE. ‘An Analytic Study of the Memory Image and the Process of Judgment in the Discrimination of Clangs and Tones.’ *Am. Journ. of Psych.*, Vols. 12 and 13.