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THE REPRODUCTION OF VISUALLY PERCEIVED FORMS

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INTRODUCTION

The object of this investigation was to observe the ways in which the reproduction of visually perceived forms varies from the original stimuli. We undertook first to compare perceived forms with the same forms as the observer subsequently draws them, and secondly to relate the difference to the observer's reports upon the nature of the perception. Since the differences are caused by factors in the processes of perceiving, remembering and reproducing, a study of these differences between the perceived and reproduced figures should yield information upon the factors.

The problem was suggested by F. Wulf's study of ideational change which appeared in 1922.¹ Wulf set out to investigate the changes in memory images which may occur with the lapse of time.

Wulf used various visual forms drawn with ink on white cards. The form was exposed on a table by uncovering the card for a period of from 5 to 10 sec, depending on the complexity of the form. After 30 sec (during which O was requested not to think of the exposed figure) O was required to reproduce the figure on paper as accurately as possible and to give a report of his experiences during reproduction, including his imagery, his estimation of the correspondence of the reproduction with the stimulus figure, and any word or meaning which had attached itself to the form. On the next day O was again required to reproduce the figure and to report. A week later the observer was shown a drawing of a small part of the original form which he was instructed to complete. This 'part-stimulus' (*Teilverlage*) was used only as an aid to O in recalling the figure. O was left in doubt as to whether or not it was exactly congruent with the

¹ F. Wulf, Beiträge zur Psychologie der Gestalt; vi. Ueber die Veränderung von Vorstellungen (Gedächtnis und Gestalt), *Psychol. Forsch.*, 1922, 1, 333-373.

corresponding part of the original. In other words, the original figure was presented only once on the first day, and the 'part-stimulus' was later given as a cue to its reproduction. The Os always remembered the figure upon seeing the 'part-stimulus'; although sometimes they changed this to accord better with what they remembered the form to be. In some cases (Wulf does not state how many) this reproduction from the 'part-stimulus' was repeated after a period of 2-8 weeks. Twenty-six figures were presented individually to six observers. The procedure outlined above, however, was not strictly adhered to for all Os. The total number of reproductions was only about 400.

Wulf concludes that the reproductions show a change either towards *sharpening* (*Präzisierung*) or *levelling* (*Nivellierung*). *Sharpening* Wulf defines as the exaggeration or emphasis of a characteristic or peculiarity of the presented figure; *levelling* as the omission, toning down or weakening of a characteristic. He found, *e.g.* in a preliminary experiment that where there were presented two curved lines side by side and convex in the same direction, one line having a somewhat sharper degree of curvature than the other, so that the two lines were closer together at the ends than in the middle, the line of lesser curvature was changed so that it curved more and became parallel to the other. This reproduction was unusual in that it showed both sharpening and levelling. There was sharpening with respect to one part of the figure, *i.e.* one characteristic (the curvature of one line) was exaggerated; but there was also levelling with respect to the figure as a whole in that another characteristic (the difference in curvature of the two lines) was eliminated. Had reproduction increased the difference in curvature of the two lines, this also would have constituted sharpening.

These two kinds of change are regarded by Wulf as two possible directions (*Richtungen*) which the forms may take in the course of memory. The change (whether sharpening or levelling) is for him *continuous*, *i.e.* the change becomes progressively larger with each subsequent reproduction, and the direction of either change remains the same.²

² "With the exception of 8 cases (of which 6 resulted either in no, or entirely strange, reproductions) the comparison of reproductions with stimulus figures shows a constant, clear variation either in the direction of sharpening or levelling, and the comparison of different reproductions of the same figure coming at different times shows that the changes overwhelmingly follow a definite direction, which as a rule is plainly indicated in the first reproduction." Wulf, p. 340.

Sharpening and levelling are, however, only the most general classes into which the changes may fall. This is only a primary classification. Wulf distinguishes three specific kinds of change which cause sharpening or levelling;—three ways in which sharpening and levelling may occur. The first kind he calls *normalizing* (*Normalisierung*), i.e. a change (presumably in the reproductions) in the direction of a familiar object. If the presented object is apprehended as a 'bridge with pillars,' the reproduction shows a modification towards the object. As a rule, the modification increases in subsequent reproductions. Wulf's explanation is that the normal or conceptual form³ of a bridge which was aroused during the perception becomes more firmly established (*sich durchsetzt*) with each succeeding reproduction. The change is still, from a logical standpoint, either sharpening or levelling. It is also, however, and more specifically, a change in the direction of a familiar object.

The second kind of change is called '*emphasizing*' (*Pointierung*). The observer notes particularly some characteristic of the stimulus figure, some peculiarity which attracts his attention, and as a result this characteristic or peculiarity is exaggerated in the reproduction. Here, Wulf states, the change is not determined by the normal structure (as in *normalizing*), but by some variation from the norm particularly noticed by the observer. If one part of a figure is noted as smaller than another, then this relationship is increased in the reproduction.

The third kind of change occurs where the mode of apprehending the figure is not a factor in causing the change, but where the cause lies in the attributes of the form (*Struktur*) itself (352). Accordingly it is characterized as a *structurally conditioned change* (*strukturelle Veränderung*). The direction of the change is determined quite independently of *normalizing* or *emphasizing*; it is due to the nature of the *structure*. A

³ 'Form' is here used as a translation of '*Struktur*,' a word very frequently used by Wulf with the apparent meaning of *general image or concept*. It is defined as "first a compact, static or dynamic, non-summative experience-cohesion (*Erlebniszusammenhang*) and next the physiological correlate belonging to it" (350). Hereafter '*Struktur*' will be translated either as 'form' or 'structure.'

form, *e.g.* tends to be drawn symmetrical even where a normalizing apprehension works in the direction of asymmetry. Here the *structurally conditioned change* is the stronger of the two (352, 356).

In addition to the classifications already described, Wulf distinguishes two types of perception, which he arrives at in the following way. The characteristics of the first reproduction, *i.e.* the changes which it exhibits, are determined in large measure by the original apprehension (*Auffassung*) of the form, which is different for different observers. The same form may be grasped as 'two triangles,' as 'letter W' or as 'mountains.' The apprehension, then, expresses the character of the perception as dependent on the observer. Wulf defines the word *Auffassung* as "The phenomenal data with respect to the conditions within the subject which contribute towards determining the data" (347). These 'apprehensions' he divides into two classes, into two general ways of apprehending forms or two types of perception. The one type is the apprehension of forms as things or familiar objects; the other is the apprehension of forms as drawings or geometrical arrangements. It is not true to say that one type goes beyond what is given, perceives *more* than the mere stimulus or *transforms* the stimulus, while the other does not. In both types a name is given to the form, and in both the form is related to objects. The difference lies in the *kind* of object. The first type involves familiar, substantial objects, whereas the second involves geometrical objects, figures or figure-parts. Apprehension in the first case might be 'mountains,' in the second 'two triangles.' Since the objects of the first type are more general and 'real' and are not limited to two dimensions, Wulf calls this the *comprehensive type*, and the second the *isolative type*. The three kinds of change described above may be found with either of these two types of perception.

Wulf states that his distinction between these two types of perception is much the same as that made by Katz,⁴ who distinguishes *central* and *peripheral types* of visual perception. In the one type, central factors exert more influence in determining the perception; in the other, peripheral factors (Katz, p. 173). In the one, the figure is

⁴D. Katz, Ueber individuelle Verschiedenheiten bei der Auffassung von Figuren, *Zsch. f. Psychol.*, 1913, 65, 161-180.

three-dimensional; in the other, plane. Katz believed that the individual tends to the one or to the other type of perception.

Still earlier Messmer⁵ had also made a distinction between two types of perception which in many ways seems to be the source of that made by Wulf and by Katz. Messmer found in experiments with tachistoscopically exposed words that some observers always perceived a complete word, similar to the stimulus word but incorrect, while others correctly perceived *parts* of the stimulus word and gradually pieced them together (202 ff.). The former observers showed fluctuating attention and tended subjectively to transform what was presented; while the latter attended steadily and transformed less. Messmer accordingly called them *subjective* and *objective types*. The relation of this to Katz's *central* and *peripheral* types and to Wulf's *comprehensive* and *isolative* types is evident.

METHOD OF EXPERIMENTATION⁶

A. Theoretical Considerations. The present investigation undertakes—as we have said—to study the changes which occur in the reproduction of forms, *i.e.* the ways in which reproductions are inexact copies of presented figures. We are concerned with objective differences between the reproductions and the standard stimulus-figure. These variations from the standard figure are taken to be indications of the mental processes occurring between the presentation and the reproduction.

The object of study, then, being these variations or 'errors,' the method of experiment must provide them in the reproductions. Favorable conditions for 'accurate' perception and 'accurate' retention must be limited so that 'correct' reproductions are not the rule. The task of the observer must not, therefore, be made too easy.

Several methods are possible. First, the exposure period may be limited to a fraction of a second. This is a traditional method for the experimental study of perception. Secondly, the exposure may be made under reduced illumination. The stimuli are presented subliminally or just liminally different from the background.⁷ Thirdly, the exposure period may be fairly long (one to several seconds); but the reproduction is deferred. This is the method which Wulf used and its purpose is to lengthen the time during which it is necessary to 'retain.' Fourthly, the exposure period may be fairly long, as before, but the stimuli used are complicated patterns which

⁵ O. Messmer, *Zur Psychologie des Lesens bei Kindern und Erwachsenen*, *Arch. f. d. ges. Psychol.*, 1903, 2, 190-298.

⁶ The experiments were carried out in the Psychological Laboratory of Princeton University, under the direction of Professor H. S. Langfeld, to whom the writer is deeply indebted.

⁷ E.g. L. Hempstead, The perception of visual form, *Amer. J. Psychol.*, 1901, 12, 185.

exceed the perceptual span.⁸ Fifthly, the exposure period may again be fairly long, but the stimuli are presented serially so that it is necessary to retain not one stimulus but several. This method is used in the present investigation. In defense of it, it may be urged that a series of perceptions coming in a group better approximates the situations of everyday life than does a single isolated perception, and that therefore the conclusions resulting from such a method would better apply to everyday perception than would conclusions based on a method using an isolated presentation.

Whether the changes occur during perception or memory, whether or not change is involved in the process of recognition, and how much change is involved in the process of reproduction, are questions which cannot easily be determined.⁹ To the present writer they are not questions of great significance. How is it possible to distinguish, except abstractly, between perception and retention, between retention and recognition, or between recognition and reproduction? It would seem that in reality what goes on between the moments of fixating a visual object and the subsequent reproduction of that object is a continuous and unitary process. Temporal distinctions between earlier and later parts of it, such as 'perception,' 'retention' and 'reproduction' may be convenient and necessary, but they should never make us lose sight of the continuous and uniform nature of the process. As Judd says in his *Studies in perceptual development*, "The tests [i.e. Judd's experiments] should not be criticised because they involve memory; it should rather be recognized that all perception involves memory, the memory phase being in general overlooked by any purely analytical method of examining experience."¹⁰

B. Description of Method. In the experiments of Group I, two series of fairly simple geometrical forms were used. Series A, the 'straight series,' consisted of 14 figures made up of straight lines. Series B, the 'curved' series, consisted of 14 figures made up of curved lines except that in four figures straight-line components were included. In both series 7 of the 14 figures had from two to four breaks or gaps in the contour. (See Charts I and II.) The maximal dimension for any figure was $\frac{7}{8}$ inch.

The figures were exposed in a modified Ranschburg Memory Apparatus.¹¹ The white cardboard exposure disc was ruled off into 15 sectors and the 14 figures were drawn within these areas on the periphery of the disc. One space was left empty. A new cover was made for the instrument with a circular window $1\frac{1}{2}$ inches in diameter. The old cover was designed for the exposure of words. The mechanism was so modified that the exposure disc rotated with a jerk through an arc of 12 degrees, or just far

⁸ E.g. C. H. Judd & D. J. Cowling, Studies in perceptual development, *Psychol. Rev. Monog. Suppl.*, 1907 (No. 34), 353.

⁹ The distinctions between these processes and an analytic treatment of the changes in a memory image, i.e. 'memory illusions,' may be found in Titchener, *A text-book of psychology*, 1924, 396-427. For a fuller treatment of changes in imagery see F. Kuhlmann, On the analysis of the memory consciousness; a study in the mental imagery and memory of meaningless visual forms, *Psychol. Rev.*, 1906, 13, 333-336.

¹⁰ Judd & Cowling, *op. cit.*, 357.

¹¹ For a diagram and explanation of this apparatus see Titchener, *op. cit.*, 381.

enough to expose a new figure, when the circuit was completed through the electromagnets. Contacts were made on a revolving brass drum driven by a constant-speed motor.

The period of exposure for each figure was approximately $1\frac{1}{2}$ sec. The observer sat at a table on which the apparatus lay. The exposure opening was normally about $1\frac{1}{2}$ feet from O's eyes; although O was allowed to change this distance to suit his convenience. He was instructed simply to look carefully at each figure and at the end of the series to draw as many figures as he remembered in any order he wished.

The experimenter sat by the side of O taking notes on the reproductions as they were made. O was encouraged to comment on his reproductions and to discuss the method used, but this was not always sufficient. Whenever a drawing showed a change from the stimulus figure and information regarding the reproduction was not volunteered, O was questioned. Care was taken, however, not to inform him how his reproduction varied from the original. 'Leading questions' as to the explanation of any such variation were avoided by asking only such questions as "Tell me about this figure" or "What do you remember about this one?" No definite time limit was set for reproduction. O was allowed to continue until he stated that he could not remember any more figures, or until he had not made a drawing for some time. The entire period of reproduction never exceeded 5 or 6 minutes.

It was planned in this first group of experiments to study both the learning of the two series of figures and the subsequent forgetting of them. The Os were to continue seeing and reproducing the forms until they were able to reproduce both series 'correctly.' Then, at intervals thereafter, they would be requested to reproduce the forms from memory. The six Os were designated Br, Ca, Do, Hu, La, and Sch. At the first experimental sitting with a given observer the cardboard disc prepared for Series A ('straight') was put into the apparatus and the figures were exposed in the manner described. O then reproduced as many forms as he could remember. The exposure was repeated, and if by this time the observer still could not reproduce more than 7 figures of the series, it was given a third time. Series B ('curved') was then put into the apparatus and it also was exposed twice and if necessary a third time, with reproduction after each exposure. At the second experimental sitting and at all subsequent sittings, before any figures were exposed the observer was required to draw from memory all of the forms he could remember from the previous sitting. After this preliminary reproduction, first for Series A and then for Series B, the figures were presented and reproduction was made in the same manner as in the first sitting. The sittings were continued (6 to 8) for each O until he could reproduce all the figures of both series.

It was found, however, that the plan of these early experiments, which was first to have the observers learn the forms and to reproduce them correctly and next to study the process of forgetting, could not be fully carried out. In the first place, no definite criterion could be found of having *learned* a figure, since there could be no arbitrary standard of the *correctness* of a reproduction. Absolute correctness would have been complete correspondence of reproduction to stimulus figure; but this never occurred. In the second place it was discovered that each O's reproductions varied from the original forms by certain characteristic changes which tended to become habitual in the later experimental sittings, and which could only partially and with difficulty be eliminated, even with repeated exposures of the pattern figures. Certain modes of apprehension, Wulf's *Auffassungen*, consistently occurred in the perception of many of the forms and conditioned these changes. In fact, when, about 5 weeks after the final exposure, the observers were requested to draw the figures of Series A and B from memory and to give an account of the process of reproduction for each, they

reverted to their characteristic modes of reproducing. A year later the same request was made of the observers and the changes were found to have persisted in those figures which were reproduced.¹² Therefore, we cannot accurately speak of learning or forgetting the forms. The observers perceive and reproduce them in certain ways, and remember them with certain modifications. Learning and forgetting are terms which involve a distinction between 'correct' and 'incorrect.' This distinction is not practicable for the learning material used in these experiments.

After the experiments of Group I had been completed, Group II was undertaken in order to study more specifically the changes appearing in the reproductions and the frequency with which they appeared. The period of exposure for each figure was two sec instead of $1\frac{1}{2}$; but otherwise the method was the same as in Group I. Twenty Os were used. No attempt was made to have the observers 'learn' the figures as was the case in Group I. Each observer was given only one experimental sitting. Series A was presented and reproductions were made. It was then presented a second time to the observer and again the observer drew the figures. Series B was then presented twice in the same manner. There were, thus, four sets of reproductions for each observer. Notes were taken on the reproductions in the same manner as in Group I, except that here, after the experiment was over, the observer could be shown the stimulus figures side by side with his reproductions and could be questioned about the changes which appeared.

RESULTS

Approximately 4,000 reproductions of the 28 figures were secured, together with E's notes taken at the time of reproduction. The reproductions showed, in greater or lesser degree, changes from the stimulus figures. These changes varied from the most insignificant to others so great that the resulting form could only with difficulty be recognized as a copy of the original.¹³ On first studying them the changes

¹² The persistence of changes will be taken up later.

¹³ Whenever in Group II a reproduction occurred which could not be clearly recognized by the experimenter as a rendering of one of the stimulus figures, the stimulus figures themselves were shown to the observer at the end of the experiment and he was requested to point out the figure which corresponded to the reproduction in question. In Group I this was impossible and hence among the reproductions of this group there are a few which could not be identified.

appeared to be of so many kinds and of such diversity that any attempt at classification seemed almost hopeless. No two reproductions were quite alike, and at first the most impressive fact about them was this uniqueness of each reproduction. Even with the comparatively simple stimulus figures used, it is evident that every reproduction is an individual phenomenon determined by very complex conditions which are never twice the same. One has only to examine a large number of reproductions of the same form by various Os to realize how numerous and complicated the determinants of perception and reproduction must be.

Nevertheless, after the changes had been studied for some time and after they had been compared with the reports of the observers, certain broad lines of classification emerged. Even after watching the reproductions of only a few observers, it became evident that resemblances to familiar objects which the observers saw in the figures were influencing the reproductions. A reproduction would be made with some unusual change, and in reporting on the reproduction the observer would mention casually (of his own accord or on questioning) that the figure looked like a particular object, *e.g.* a maid's apron, a fish's tail or a geological formation. It would at once become clear that the change had been of such a nature that the reproduction conformed more closely to the object than did the original. On the other hand, it frequently happened that the observer analyzed the figure verbally in such terms as 'triangle with square on top' or 'base with top part slanting.' The reproduction which followed was altered in the direction of the verbal memory. Still another kind of change could very often be distinguished in which one figure had plainly modified the reproduction of another. The observer, let us say, had drawn one form and this apparently reminded him of another which he also proceeded to reproduce. This latter form showed a change in the sense of having taken on some of the characteristics of the first form. On being questioned, the observer would state that he had remembered the latter form as *similar* to the first. This kind of change may be said to be comparable to the first kind mentioned,

except that in this case one of the stimulus figures takes the place of the familiar object. Furthermore, a certain class of changes peculiar to the 'broken' figures—those having gaps in the contour—could be distinguished. As a general rule, the gaps were reproduced smaller in the reproductions or were entirely closed up; but now and then one occurred in which the essential form of the stimulus figure had entirely disappeared. The gaps had widened and the figure had, as it were, fallen apart. It was no longer a shape, but instead two or more scattered parts of the original. Finally, a class of changes peculiar to the 'curved' figures could be made out. Occasionally one of these stimulus figures was reproduced partially or wholly in terms of straight lines. The opposite phenomenon, that of reproducing part of a straight figure as curved, never occurred. This type of change did not occur, however, with sufficient frequency in the reproductions of Groups I and II definitely to establish its validity. A separate group of experiments, to be described later, demonstrated its right to a distinct classification.

The names given to these classes of change were, in the order in which they have been described, Object Assimilation, Verbal Analysis, Figure Assimilation, Completion or Disintegration and Rectilinearity. These words do not by any means denote hard and fast categories. The classes of change are not mutually exclusive. Very frequently a reproduction shows two or more kinds of change. Object Assimilation and Completion are very often found in the same reproduction. Verbal Analysis and Disintegration are likewise often found together. With the exception of Completion and Disintegration, which are logically opposed, any kind of change may enter into combination with any other to determine a reproduction and examples may be found of all these combinations. Object Assimilation, Verbal Analysis, Figure Assimilation, Completion and Disintegration, and Rectilinearity, then, are merely descriptive names which are used to denote a few general influences among the numerous and complicated factors which determine perception and reproduction.

In order to determine the frequency with which these

kinds of change occurred, a study was made of the reproductions of Group II. Rectilinearity was not included in this study since, as was mentioned, a later group of experiments was devoted to it. The 20 observers of Group II had made a total of 689 reproductions out of a possible 1,120 figures exposed. 294 of these reproductions (43 per cent) clearly showed changes which could be classified under the five kinds (omitting Rectilinearity) described above. The results are shown in Table I.

TABLE I

CHANGES OBSERVED IN GROUP II

Obs.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Totals
Object																					
Assim...	8	1	3		8	2	2	3	12		2	2	9	7	6	6	12	1	7	4	95
Verbal Analysis...		2		1				1	1	4		1	1		2		1		1	2	17
Figure																					
Assim...	5	5	6	2	7	2	5	7	6	7	2	2	10	6	3	9	11	2	6	5	108
Comple-		2		3		1	2		10	10	6	4	7	1							48
Disintegra-		2	2	1	4	1	1	6	2				1			1	4			1	26
Total																					
changes.	17	10	13	7	17	7	14	13	28	21	10	10	27	14	12	19	24	3	14	14	294
No. of re-																					
productions.	47	33	37	21	36	24	35	29	49	29	42	22	37	44	35	28	46	32	32	31	689

Several rules were adopted in listing the changes. In general, a change was listed only when it could be clearly recognized as falling into one of our five classes. Doubtful cases were omitted. No change was counted as Object Assimilation or Verbal Analysis unless the notes on the report of the observer explained the change. A change was placed under the head of Figure Assimilation only when either the notes or the order of reproduction explained the change, or when the change was so obviously in the direction of another figure that any other explanation was impossible. Completion was counted only when one or more gaps were wholly closed up, not when the gaps were merely drawn smaller. There was no difficulty in the case of Disintegration since, when it occurred, it was always easy to recognize.

When two or more kinds of change were exhibited by the same reproduction, only the change which appeared most

evidently to have determined the reproduction was catalogued. Therefore the table does not show the total number of times that a particular kind of change occurred in the reproductions, but only the number of time when that particular change had more effect than any other. If *all* the changes had been listed, including those cases where two or more kinds coincided in the same reproduction, the number would have been increased by at least 10 per cent.

It will be seen from Table I that Figure Assimilation is the most frequent kind of change, with 108 out of the 294 reproductions listed, or 16 per cent of the total number of reproductions made. Object Assimilation is the next most frequent, with 95 reproductions constituting 14 per cent of the total. Completion and Disintegration, with 48 and 26 reproductions respectively, together make up 11 per cent of the total. The last two kinds of change, however, can occur only in the 'broken' reproductions. When this fact is taken into account, it appears that Completion or Disintegration occur in 23 per cent of the 315 reproductions in which it is possible for them to occur. Verbal Analysis concludes the list with 17 reproductions or 2 per cent of the total.

A. Object Assimilation

Precisely defined *Object Assimilation is the term used to describe the phenomenon in which the perception of the figure involves visual or verbal imagery of some familiar object or shape,*

EXPLANATION OF CHART I

(Os' designations of objects perceived)

- FIG. 1. (1) Staircase; (2) ventilator (*i.e.* ventilator on deck of ship); (3) stairs; (4) steps.
- FIG. 2. (1) Lampshade (also shows Completion).
- FIG. 3. (1) Pyramid with top on it (could also be considered as Verbal Analysis); (2) axe; (3) anvil; (4) bell.
- FIG. 4. (1) Letterbox (also shows Completion).
- FIG. 5. (1) Spade handle; (2) moosehead; (3) hammer (*i.e.* head of hammer).
- FIG. 7. (1) Star; (2) bird; (3) arrow; (4) arrowhead; (5) arrow.
- FIG. 8. (1) Triangle with one acute angle (also shows Completion).
- FIG. 9. (1) Face (*i.e.* profile of head); (2) face; (3) irregular medieval figure.
- FIG. 11. (1) Hourglass; (2) tilted anvil.
- FIG. 12. (1) Tub (also shows Completion).
- FIG. 13. (1) Triangle.

CHART I

THE STIMULUS FIGURES OF SERIES A AND EXAMPLES OF OBJECT ASSIMILATION FROM THIS SERIES

1		2		3		4		5		6		7	
8		9		10		11		12		13		14	
1		 											
2													
3		 											
4													
5		 											
7		 											
8													
9		 											
11		 											
12													
13													

Explanation on opposite page

and where the reproduction which follows is clearly changed so that it more nearly resembles the familiar thing than does the stimulus figure. The fact that the sight of the figure did call up, among other experiences, visual and verbal images is abundantly proved by the notes. Meanings and names were reported by all observers as having been present during the perception of at least several figures. Detailed reports were not required of any of the observers but nevertheless many of them described specific visual images, verbal images, incipient vocal movements, and less specific contents such as 'feeling of triangelness' and the like. One observer even stated definitely that he saw the forms *as objects*. He had names for all of them and perceived nearly all of them as three-dimensional and possessed of solidity. Object Assimilation was very frequent in this O.

The concomitant objects or meanings which became attached to the forms arose in two ways. Usually, according to the reports, the associations arose spontaneously; but in the case of many Os in Group II an effort was made to think of objects which were similar to the figures. Obs. F, for example, when half-way through the first exposure series, thought of 'calling figures names' and thereafter found it easier to remember them. The same observer later reported that the 'hard ones are those that don't remind you of anything.' In effect, a voluntary effort was made to think of objects by means of which the figure could be 'understood,' and the names served as cues or helps for memory.

EXPLANATION OF CHART II

(Os' designations of objects perceived)

FIG. 4. (1) Woman's torso; (2) footprint on the sands of time; (3) dumbbell; (4) violin; (5) dumbbell.

FIG. 5. (1) Two halves of an egg; (2) egg (also shows completion); (3) magnets pulling at one another; (4) egg (also shows partial completion).

FIG. 6. (1) Battle axe (dotted lines drawn by observer to show handle); (2) maid's collar or apron; (3) Napoleon's hat; (4) helmet; (5) dress shield.

FIG. 7. (1) Half an egg.

FIG. 9. (1) Club; (2) electric light bulb (O was "not positive about the lines inside"); (3) hairpin; (4) end of baseball bat with label around it; (5) loaded doll (*i.e.* with lead in the base so as to bob up when pushed over); (6) sector; (7) pestle; (8) electric light bulb.

CHART II

THE STIMULUS FIGURES OF SERIES B AND EXAMPLES OF OBJECT ASSIMILATION FROM THIS SERIES

1		2		3		4		5		6		7	
8		9		10		11		12		13		14	
4													
5													
6													
7													
9													
10													
12													
13													
14													

Explanation on opposite page

FIG. 10. (1) Blastula stage; (2) crescent; (3) moon. (It was established that the last two reproductions were not meant for Fig. 13.)

FIG. 12. (1) Triangle.

FIG. 13. (1) Horns; (2) horned toads (later called pair of horns by O).

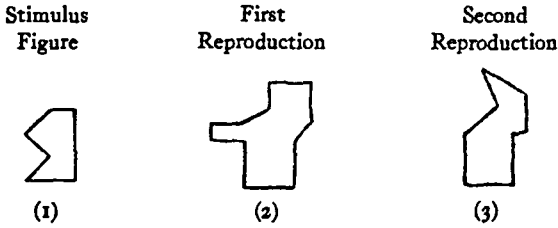
FIG. 14. (1) Meat chopper; (2) boy's top upside down; (3) basket.

The observers of Group I, on the other hand, had been instructed to try to remember the stimulus forms as strictly as possible in terms of visual images. The associations which arose during the perception of the figures were therefore quite involuntary. It was as if the figures were apprehended as *objects* and not merely as *resembling* objects. Meaningful visual and verbal images occurred without O's volition. Hu reported, for example, that during the perception of Fig. 9, Ser. A (Chart I) the stimulus form "suddenly coincided with (aroused?) the visual image of a man's face." And again that during the perception of Fig. 7 of the same series "'arrow' was explosively pronounced."

The instructions given in Group I led the Os to attempt to inhibit these meaningful associations which arose spontaneously. It was found impossible to do this, however, and all the observers in the group had well established 'object associations' by the time the experiments were concluded. In the case of Do, the attempt to inhibit the logical verbal associations which arose led to the use of nonsense words and somewhat imaginative objects as associations. Fig. 1, Ser. A was a 'goofus'; Figs. 3 and 5 were 'dishpans sitting on a fulcrum'; Figs. 2 and 12 were 'brothers'; Fig. 13, Ser. B was 'horned toads,' etc. In the last example the phrase was used merely to carry the meaning of 'horns.' The observer did not have a very definite idea of what horned toads looked like and this verbal phrase was merely the result of attempting to inhibit 'horns' as an association. (See reproduction of this O in Chart II.) In later sittings 'horns' or 'a pair of horns' became the definite verbalized meaning of the figure. The figure was never perceived as one form, a crescent with gaps, but always as two things, a pair of horns.

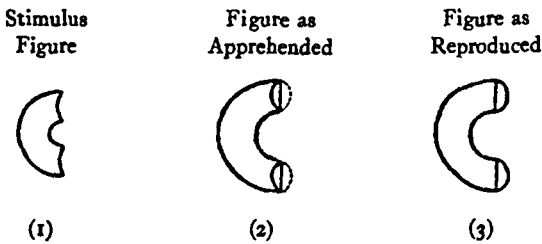
The meaning which a form had acquired did not always consist of a specific object. Observer N in Group II perceived Fig. 9, Ser. A as 'very irregular, medieval, jutting out.' His reproduction was as shown in (2). Eight months later he remembered the figure still as 'an irregular Gothic figure,' and drew (3). No specific object was here reported in imagery; but evidently the concept of 'medieval, jutting out, Gothic'

had influenced the reproductions. Certain elements of Gothic architecture, buttresses, spires, and the like may have been included in the concept together with the notion of



'irregular' and 'jutting out.' No change in the direction of a single memory image, however, which is the phenomenon usually characterizing examples of Object Assimilation, can be detected.

Another example of the way in which conceptual matter, in the absence of a definite image, may influence reproduction is found in the following drawing from a later series of experiments. The stimulus figure was apprehended as the near



side of the solid object illustrated in (2). The meaning of the figure to the observer was 'half a doughnut,' the word 'half' carrying the meaning of a half doughnut divided again into a front and a rear half. Only this general idea of a special sort of 'half' was retained in memory and when the observer came to reproduce the figure he drew the far side or 'half' of the object instead of the near side.

It may be thought that the examples which have been given in the last few paragraphs might well be classified under Verbal Analysis instead of Object Assimilation. There is some justification for such a view. The line of demarcation between the two types of change is by no means distinct and

many changes are found which could almost as easily fall into one category as the other. This difficulty will be discussed in the next section.

References to phenomena quite comparable to Object Assimilation may be found in several writers on perception. The type of change which Wulf called *normalizing*, i.e. a change in the direction of familiar objects, is clearly a similar phenomenon. In an investigation of the changes in orientation or position of reproduced figures, Meyer notes that errors in form frequently occurred and gives several causes for such errors.¹⁴ It was observed that the 'memory helps,' that is to say the objects which were associated with the figures, sometimes caused errors. In these cases, the reproduction was made more similar to the object than the original figure had been. A second source of errors was the 'familiarity-tendency' (*Geläufigkeitstendenz*). An inclination was observed to reproduce the forms more similar to familiar and frequently drawn figures, such as the letter M, a triangle, etc. Both of these two causes of errors can be brought under what has here been called Object Assimilation.

Katz, who was mentioned in the introduction as having made the distinction between central and peripheral types of perception, noted that some of the reproductions made by observers of the central type were changed in the direction of familiar objects.¹⁵

Granit¹⁶ published a number of reproductions made by children and showed that, although the forms used as stimuli bore little or no resemblance to objects, the reproductions nevertheless were strongly modified in the direction of similarity to animals and things which the children saw in the figures. Even the seemingly most meaningless ink blots were perceived by the children as 'pictures,' and the reproductions were representations of these pictures rather than copies of the stimuli.¹⁷

B. Verbal Analysis

The second kind of change which may be distinguished in the reproductions has been designated as change due to verbal

¹⁴ P. Meyer, Ueber die Reproduktion eingepprägter Figuren und ihrer räumliche Stellung bei Kindern und Erwachsenen, *Zsch. f. Psychol.*, 1913, 64, 43 f.

¹⁵ D. Katz, *op. cit.*, 165-168.

¹⁶ A. R. Granit, A study on the perception of form, *Brit. J. Psychol.*, 1921, 12, 234 f.

¹⁷ There is evidence that memory images undergo a change in the direction of the object. Kuhlmann (On the analysis of the memory consciousness for pictures of familiar objects, *Amer. J. Psychol.*, 1907, 18, 411) states that "the imagery tends with the lapse of time towards the imagery of the object represented by the picture, and with this change, takes on characteristics that belong to the object but which are not represented in the picture." Smith (An experimental investigation of perception, *Brit. J. Psychol.*, 1914, 6, 337 ff.) finds this same tendency in imagery for tachistoscopically exposed figures and concludes that the change towards the imagery of the object represented may, under his conditions, be immediate. Jean Philippe concludes from his study of the evolution of memory images (*Sur les transformations de nos images mentales*, *Rev. phil.*, 1897, 43, 486-492, and later *L'image mentale; evolution et dissolution*, 1903, 113-130.) that an image may, in the course of memory, approximate more and more to the type in which it belongs. A remembered Japanese face is reproduced more and more like the typical European face. In general, images change towards a pre-existing type, which exercises upon them a sort of attraction.

analysis. It occurs when the stimulus form, instead of being associated with a single familiar object or shape, is analyzed verbally in any of a variety of ways and when the reproduction is so changed that it is wholly or partially a product of the verbal analysis rather than a representation of the form itself. Some examples of this type of change are given in Chart III. The figure may be analyzed into geometrical forms in a certain relation to one another, or into several familiar objects or shapes in combination. Or the analysis may be in terms such

CHART III

EXAMPLES OF VERBAL ANALYSIS

1		(1)	(2)	(3)	6		(1)	(2)	(3)	
2		(1)	(2)	(3)	7		(1)			
3		(1)			8		(1)			
4		(1)	(2)			9		(1)		
5		(1)			10		(1)	(2)		

EXPLANATION OF CHART III

(Os' designations of objects)

FIG. 1. (1) Pillars with curve (also shows Disintegration); (2) reproduction of same after second exposure; (3) megaphone in bowl.

FIG. 2. (1) Thing with two little humps; (2) reproduction of same after second exposure; (3) thing with circles taken out.

FIG. 3. (1) Two things facing one another (also Rectilinearity).

FIG. 4. (1) Half moon disconnected in two places; (2) moon broken in half (also Disintegration).

FIG. 5. (1) One circle inside another.

FIG. 6. (1) Sloped down; (2) the opposite of Fig. 7 (might also be considered Assimilation with Fig. 7); (3) point with square on top (might also be considered Object Assimilation).

FIG. 7. (1) Square on triangle (might also be considered Object Assimilation).

FIG. 8. (1) Thing with an indentation.

FIG. 9. (1) Two lines inside two others (also Disintegration).

FIG. 10. (1) Two rectangles fused; (2) two things going up and out.

as 'little humps,' 'bites taken out,' 'slanting down,' 'broken in half,' etc. An observer who has made a verbal analysis of a figure is apt to have at best only weak visual imagery accompanying it, so that whatever visual image was present at the time of perception has faded to a considerable extent by the time he comes to reproduce. What he has retained is the verbal phrase and reproduction is made in accordance with this. If the analysis was careful and the description adequately represented the figure, the reproduction was usually relatively unchanged or 'accurate.' But if, as was often the case, the analysis was hasty and superficial and was inadequate the reproduction was inadequate in the same sense.

This type of change is, as was mentioned earlier, closely related to Object Assimilation and the distinction between the two kinds of change must not be thought of as sharply drawn. Reproductions may be found which possess the characteristics of both Object Assimilation and Verbal Analysis, and which can only arbitrarily be categorized as either the one or the other. For example, 'pair of horns' (Chart II, Fig. 13, 2d reprod'n) and 'moon broken in half' (Chart III, Fig. 4, 2d reprod'n) are very difficult to classify. In both cases the figure, a crescent with gaps, had been apprehended as what might be considered an object, and in both cases there had been verbal analysis. To make classification even more difficult, both figures exhibited Disintegration. It was decided that 'pair of horns' could better be considered as an object rather than as Verbal Analysis, and that the reverse was true of 'moon broken in half.'

Despite this close relation between Object Assimilation and Verbal Analysis, however, there are two ways in which they may generally be distinguished. The first is the fact that with Object Assimilation the figure is usually apprehended as a whole, whereas with Verbal Analysis the figure is usually apprehended in parts. For example, 'triangle' (Chart II, Fig. 12, 1st reprod'n) and 'square on triangle' (Chart III, Fig. 7, 1st reprod'n) are similar, in that much the same thing has occurred in both instances. That is to say, both reproductions are quite evidently in large part deter-

mined by the verbal memory. But, in the former example, 'triangle' was apprehended as a whole, while 'square on triangle' was apprehended by parts. This distinction explains why on the one hand Object Assimilation and Completion are so often found in the same reproduction, and on the other why Verbal Analysis and Disintegration are so often found together. The second way in which the two kinds of change may be distinguished lies in the fact that the imagery occurring with Object Assimilation is predominantly visual, while that occurring with Verbal Analysis is predominantly verbal.

Characterized in these two ways, the distinction between Object Assimilation and Verbal Analysis bears some relation to Wulf's distinction between comprehensive and isolative types of perception. In the former type, it will be remembered, the figures are seen as things or as pictures of things while in the latter type the forms retain their individuality as drawings. In the first case, the apprehension is in terms of familiar, substantial objects; in the second, in terms of geometrical figures and figure-parts, such as triangles, curves, squares, slanting lines, etc. The configurations of the comprehensive type are three-dimensional and lifelike and are apprehended as a unity; those of the isolative type are two-dimensional and are analyzed into parts which may be apprehended in various ways.

Although these types of perception make a distinction between whole and part apprehension and may to this extent be compared with Object Assimilation and Verbal Analysis respectively, nevertheless the present results do not indicate either that the latter constitute types of perception or that they are as distinct and separate from one another as are Wulf's comprehensive and isolative types. Wulf seems to mean, although he nowhere states, that observers differ in possessing either one or the other type of perception. Such a conclusion could not be drawn from the present data. Object Assimilation and Verbal Analysis are regarded not as types of perception, but primarily as types of change found in the reproductions and secondarily as general influences at work in the perceptual process. Subjectively they may be con-

sidered ways of perceiving—as wholes or parts, in terms of visual or verbal imagery—but this does not make them types in Wulf's sense. Both Object Assimilation and Verbal Analysis are factors which are at work in every individual's acts of perceiving visual forms. It may be that individuals differ in the relative amounts of influence which these factors exercise in perception, but this question could not be settled by the results here obtained.

Another writer has noted changes which are directly comparable to Object Assimilation and Verbal Analysis. Kuhlmann, who studied the 'memory consciousness' and, to some extent, the reproductions of nonsense forms for a period of 90 days after presentation, finds three causes for 'errors' in the images and in the reproductions.¹⁸ They are (1) Ambiguous Verbal Description, "The subject might, for instance, note that a form was made up of certain familiar parts, curves, straight lines, angles, etc. . . . 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." (2) The Influence of Associations. "The influence consisted simply in changing the form so as to resemble the associated thing more than the original form as presented did. . . . 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 the real form without any suggestion of error to the subject." (3) The Influence of Certain Standards in Forms, Positions, and Relations. Kuhlmann here includes tendencies which he finds for the forms to become symmetrical, to approach familiar geometrical figures, for lines to become parallel, etc. Clearly the first two causes of 'errors' correspond closely with change due to Verbal Analysis and with Object Assimilation respectively. Kuhlmann does not give examples of any reproductions, however, as he is primarily concerned with the introspective descriptions.

C. *Figure Assimilation*

Figure assimilation in its simplest form may be defined as the phenomenon where one of the stimulus figures is apprehended by the observer as in some respect similar to a second stimulus figure, and where the ensuing reproduction is clearly changed so as to resemble the second figure more closely than does the original. Frequently, however, the situation is more complicated. When two figures are perceived as similar, the influence of one on the reproduction of the other may be mutual. And

¹⁸ F. Kuhlmann, On the analysis of the memory consciousness; a study in the mental imagery and memory of meaningless visual forms, *Psychol. Rev.*, 1906, 13, 335 f.

furthermore three or even more figures may be involved, each influencing the others in greater or lesser degree. There are, in fact, three grades or degrees of figure assimilation to be found in the reproductions. For the sake of simplicity, assimilation between two figures only is considered.

1. A condition where one figure was reproduced without significant change but where the other was assimilated to it, *i.e.* was changed in the direction of the first figure.

2. A condition where each figure was changed in the direction of the other, *i.e.* each took on some of the characteristics of the other.

3. A condition where only one reproduction was made, which was a combination of the two stimulus figures or of some of the characteristics of each.

Examples are given of each of these three types of assimilation in Chart IV.

The actual changes brought about in the reproductions by Figure Assimilation are of many kinds. Not only may a change in the shape of a figure be caused by assimilation to another figure, but also a change in size, or in proportions, in position or orientation, and, for the 'broken' figures, in the number and location of the contour gaps. This influence of one figure on another may bring about the suppression of a characteristic or the addition of a new one, the omission of line components or the introduction of further elements. Furthermore, Figure Assimilation quite frequently enters into combination with other kinds of change. It is often found in conjunction with Object Assimilation and with Verbalization, and less frequently with Completion or Disintegration.

The fact that perception of some sort of similarity or resemblance between figures did occur is evidenced not only by the reports of the observers but also by the order in which reproductions were drawn. A drawing which had just been completed reminded the observer of another figure which he proceeded to draw next. This second reproduction often showed assimilation to the first one. Whether the association between the two figures, *i.e.* the recognition of their similarity, occurred at the time of perception or just before reproduction

CHART IV

EXAMPLES OF FIGURE ASSIMILATION

Type 1		Type 2		Type 3	
Stimulus Figures	Repro- ductions	Stimulus Figures	Repro- ductions	Stimulus Figures	Repro- ductions
(1)		(2)		(3)	
(4)		(5)		(6)	
(7)		(8)		(9)	
(10)		(11)		(12)	
(13)		(14)		(15)	
(16)		(17)		(18)	

was made is a question which usually cannot be answered. The observers were often scarcely aware of such similarities. One figure merely made them think of another. The association had not risen to a verbal level and may have been very vague. With the observers of Group I, however, who saw the stimulus forms again and again, quite definite associations between different forms arose. The figures were remembered as falling into groups or classes, with from two to four figures in a group. Assimilation within these groups was quite common.

The perception of similarity between two or more figures by an observer was frequently complicated by the simultaneous perception of other relations between the figures than similarity. For example, in addition to perceiving a general resemblance in shape an observer would notice a particular difference between two figures, such as in Example 13, Chart IV, where one figure went 'in' and the other 'out.' The difference which was noticed between the figures was usually carried in verbal terms and changes resulted in this way which could be considered as partly due to Verbal Analysis. In Examples 16 and 17 the stimulus figures were perceived as similar except that, in a sense, one was the reverse of the other. This general idea or verbal memory of reversal conditioned the changes shown. Example 11 also shows a very similar phenomenon.

Figure Assimilation, as was stated earlier, is the most frequent kind of change to be found in the reproductions. 16 per cent of the reproductions of Group II show it clearly, or 108 out of the 689 drawings. The explanation of this fact and also of the additional fact that Figure Assimilation has not been noted in other experiments involving the reproduction of forms, except those of Meyer which will be described shortly, is undoubtedly to be found in the method used in the present experiments. Conditions were especially favorable for the influencing of one figure by another. In the first place the stimulus forms were presented in series, one immediately after another, and reproduction was required only at the conclusion of the series. The observer had to remember the

forms in a group. In the second place, all the drawings subsequent to any one exposure series were made on the same sheet of paper. The forms of a series were not only remembered together but were reproduced together. Slight associations already existing between two or more figures would be strengthened by this procedure. In her investigation of the spatial orientation of reproduced figures Meyer¹⁹ mentions briefly that infrequently there occurred in the reproductions an associative fusion-effect (*Mischwirkung*). That is to say, the essential characteristics of two presented figures were found in one reproduction. This is clearly Figure Assimilation. The significant fact that Meyer used the same method of presentation which was adopted for these experiments, the exposure of stimuli in series, lends weight to the above conclusion that Figure Assimilation is a product of the method used.

It should be mentioned that, as a result of this method of presentation, retroactive inhibition occurred during the exposure of the series. The observers often complained that each figure as it appeared 'blotted out' the preceding figure. This inhibition was sometimes so strong that, at the end of the series when reproduction was to be made, the observer maintained that he could not remember any figures, or at best only the last of the series. Almost invariably, however, when the observer had drawn one or two figures, he suddenly remembered another and then perhaps several others until he had completed a fairly full list.²⁰

D. Completion and Disintegration

The types of change which have hitherto been considered are general in the sense that they apply to all the stimulus figures alike, 'straight' or 'curved,' 'broken' or 'complete.' Completion and Disintegration, however, are specific kinds of change occurring in the broken figures only, by virtue of their essential characteristic—that of having an interrupted or broken contour. *Completion occurs when the stimulus figure*

¹⁹ P. Meyer, *op. cit.*, 42.

²⁰ The average number of reproductions made after the first exposure of a series to an observer was between 7 and 8 out of a possible 14.

is apprehended as a single form, despite the gaps, and when the reproduction is drawn with a continuous contour. Disintegration occurs when, on account of the gaps, the figure is apprehended not as a single form but as two or more pieces or segments, and when the reproduction is drawn with such a widening of the gaps as to make the figure fall apart and lose its characteristics as a form. An observer whose reproduction exhibits Completion may or may not have seen the gaps in the stimulus figure. But he had apprehended the figure as essentially a single, unitary form. The gaps were not significant parts of the perception, and the figure was reproduced, accordingly, as a complete form. For example, Obs. A in Group II, upon first seeing Series A, reproduced two of the broken quadrilaterals without gaps. After the second exposure, as if having noticed the gaps for the first time, he reproduced the same two figures with gaps at all four corners. Obs. Sch in Group I, after having seen the forms repeatedly and therefore having become fully aware of the gaps, still so definitely perceived the broken figures as wholes that he adopted the habit of drawing a continuous contour and then erasing out a few gaps in appropriate locations.

Absolute Completion, as defined above, *i.e.* the closing up or disregarding of all the gaps of a figure, occurred in only about 15 per cent of the broken reproductions. But if the cases of partial completion are counted, which include both reproductions where the gaps are fewer in number and reproductions where the gaps are drawn smaller, almost all the broken reproductions except the 8 per cent exhibiting Disintegration will have been accounted for. In particular, the quadrilateral figures of Series A were consistently reproduced by all observers with smaller and sometimes with fewer gaps. Two examples of partial completion for Series B figures are given in Chart V. They are Fig. 8, 2d reprod'n and Fig. 10, 2d reprod'n.

Disintegration involves a type of apprehension wholly different from that described above. An observer whose reproduction shows this kind of change has perceived not a single form but instead a number of lines or angles which are

CHART V

EXAMPLES OF COMPLETION AND DISINTEGRATION

Stimulus Figure	Examples of Completion	Examples of Disintegration
1 	(1) 	(2)
2 	(1) 	(2) (3) (4) (5) (6)
3 	(1) 	(2) (3) (4) (5)
		(6) (7) (8) (9)
4 	(1) 	(2) (3) (4) (5)
5 	(1) 	(2)
6 	(1) 	(2) (3) (4)
7 	(1) 	(2) (3)
8 	(1) (2) 	
9 	(1) 	(2) (3)
10 	(1) (2) 	(3) (4) (5)

Explanation on opposite page

usually only vaguely related to one another in position. Obs. G, Group II, after having made two reproductions showing pronounced disintegration, stated that "there were a lot of angles [referring to the first four quadrilateral figures in Chart V]. There ought to be about four but I can only remember two." Among the reproductions of this O, who saw the broken figures as a 'lot of angles,' there were 10 instances of Disintegration. No Completion occurred.

The kind of apprehension which leads to Disintegration is closely analogous to that which occurs in Verbal Analysis. In both types the figure is perceived not as a whole or unit but in parts. As may be seen from the explanatory notes on Chart V and also from those on the broken reproductions of Chart III, Disintegration and Verbal Analysis are frequently found in the same reproduction, and it is sometimes impossible to say whether a change is one thing or the other. (For example, Chart V, Fig. 5, (2), and Chart III, Fig. 9, (1); also Chart V, Fig. 9, (3), and Chart III, Fig. 1, (1) and (2); also Chart V, Fig. 10, (4), and Chart III, Fig. 4, (2).) Conversely, Completion and Object Assimilation frequently are found to-

EXPLANATION OF CHART V

(When no notes are given on a reproduction, the drawing is either self-explanatory or O made no report.)

FIG. 1. (2) Disintegration and also simplification to triangle.

FIG. 2. (2) Two lines. (The left-hand line was especially vivid and hence correct. Also note symmetry); (4) two angles; (5) the same after second exposure. Note that right angle was correct.

FIG. 3. (2) Symmetry; (3) simplification to triangle; (4) simplification; (5) symmetry; (6), (7), (8), (9), four reproductions by Hu, Group I, of this figure after four consecutive exposures. (6) and (7) were merely perceived as angles facing one another, although in (7) the lower one was noted as a right angle. In (8) there is still assimilation to the old apprehension, although the linear relations are correct. In (9) the reproduction is nearly accurate.

FIG. 4. (4) Unconnected lines.

FIG. 5. (2) Four lines, the horizontal inside the vertical (also Verbal Analysis).

FIG. 6. (1) Completion plus Object Assimilation: parallelogram.

FIG. 7. (1) Completion plus Object Assimilation: egg.

FIG. 8. (2) Example of partial completion.

FIG. 9. (1) Completion plus Object Assimilation: electric light bulb.

FIG. 10. (2) Example of partial completion; (3) two points (also Verbal Analysis); (4) two things pulled down at each end (also Verbal Analysis); (5) observer merely perceived two things facing one another and remembered that they were curved.

gether in a reproduction of one of the broken forms. The perception occurring with these two kinds of change is typically of a single thing. The distinction therefore between whole and part apprehension which was made with regard to Object Assimilation and Verbal Analysis is here further corroborated.

In connection with the reproductions given in Chart V, two particular factors should be noted which are effective in determining the nature of the reproductions. First, when Disintegration occurs and a figure is reproduced merely as a group of lines or angles, there is a tendency to draw the lines or the angles in such a way that they are symmetrically related as to position. The form which holds the lines in place having disappeared, the next best determiner of position is symmetry. This factor of symmetry in determining the reproductions of figures has been noted in several experimental studies.²¹ Secondly, in several of the reproductions of the first four quadrilateral figures given in Chart V, it may be seen that the grouping of lines and angles has taken the general form of a triangle. This phenomenon has been indicated in the explanation of the chart as 'simplification.' There is apparently a tendency towards a three-sided arrangement in reproduction when the original four-sided form is not perceived as such.²²

E. Rectilinearity

Just as the types of change last discussed depend upon the use of broken and complete figures as stimuli, so the kind of change now to be considered arises in connection with the

²¹ See P. Meyer, *op. cit.*, 42; A. R. Granit, *op. cit.*, 237-240; L. Hempstead, *op. cit.*, 188; and F. Kuhlmann, On the analysis of the memory consciousness; a study in the mental imagery and memory of meaningless visual forms, *Psychol. Rev.*, 1906, 13, 336.

²² With regard to Completion, a few investigators have referred to a tendency to fill in or complete figures when reproduced. Hempstead, *op. cit.*, 187, finds a disposition towards "the formation of a continuous from a discontinuous figure." Meyer, *op. cit.*, 42, notes as one of the types of errors found in the reproductions the completion of a figure, and gives as an example a case where an acute angle had been reproduced as a triangle. F. Meakin (*Mutual inhibition of memory images, Psychol. Monog.*, 1903, 4, 263) finds that the visual memory image of a broken form has a strong tendency to be completed when the broken form was presented side by side with the completed form. No mention of anything similar to Disintegration has been found in the literature.

straight and curved figures. It had been observed in some of the reproductions of Series B, the curved figures, that occasionally part or all of the drawing would be made in terms of straight lines. The opposite phenomenon, that of reproducing part of a straight figure as curved, never occurred. These facts seemed to indicate that when an observer is not clear as to the nature of one or more component lines of a form, he is more apt to reproduce them straight than curved.

To test this hypothesis and also to find out whether or not there was any significant difference between straight and curved figures in perception and memory, a new group of experiments was undertaken (Group III). Two new series of forms were made up, 25 of which were composed of straight lines and the other 25 of which were composed entirely of arcs of circles. In the attempt to make the two series comparable, the figures of the two series were constructed as far as possible so that they were of the same order of complexity or 'difficulty.' The 25 straight figures had an average of 4.6 sides. The 25 curved figures (counting a 'side' an arc of 180° or less) had an average of 4.3 sides. On this basis of comparison, the straight figures were slightly more complex than the curved figures.

The stimulus figures were drawn on the faces of blank playing cards and were exposed by placing one card after another on a table in front of the observer, each card covering the one just presented. One card was exposed every two seconds, the time being regulated by following the rhythm of a half-second pendulum which was allowed to beat throughout the experiment. The cards were shuffled anew for each new O, so that in contrast to the experiments of Groups I and II, the order of presentation did not have any influence in the reproductions taken as a whole. 15 observers were used. With five of these the 25 curved figures were exposed and reproduced, then the 25 straight figures. The order of exposure was reversed for alternate subjects. With another five Os, all 50 figures were presented in one series, the figures being arranged in chance order. With the remaining five Os, ten figures were presented at a time, each ten consisting of five

straight and five curved figures. Reproductions were made after each group of ten figures.

For each of the three methods of presentation more straight figures were remembered than curved, even though, as was mentioned, the straight figures were slightly more complex than the curved. Out of 277 reproductions, 149 were straight and 128 curved, an advantage of 17 per cent for the former. More important than this, however, was the fact that approximately 20 per cent of the curved reproductions exhibited

CHART VI
EXAMPLES OF RECTILINEARITY

Stimulus Figure	Reproduction	Stimulus Figure	Reproduction	Stimulus Figure	Reproduction

rectilinearity, *i.e.* had straight line components instead of curved. Less than 3 per cent of the straight reproductions had curved lines, and these instances occurred in the last two methods where straight and curved figures were presented together. That is to say, the chances being equal, more curved parts of figures were reproduced straight, than straight parts curved.

In order to find out whether this fact might be due to the effect of Figure Assimilation between straight and curved figures, the former tending to assimilate the latter more than the reverse, the 25 curved figures alone were presented to five new Os. It was found that curved parts were still reproduced straight. About one-fifth of the reproductions showed this type of change. There seems to exist, therefore, a genuine change in the direction of the rectilinear. The change is independent of the presence of straight-line figures among the stimuli, and is apparently due to a factor in the perception

of curved figures. Chart VI contains a few examples of these changes from curved lines in the stimulus figures to straight lines in the reproductions.

THE RESULTS OF WULF AND THOSE OF THE PRESENT EXPERIMENT

A. Sharpening, Levelling and Structurally Conditioned Change. It will be remembered that Wulf classified the changes exhibited by his reproductions in two ways. Primarily, all changes fell either into the category of sharpening or into that of levelling. Secondly, the changes were caused either by normalizing, emphasizing or the characteristics of the 'structure' itself.

With regard to the first classification, sharpening and levelling were defined respectively as the exaggerating and eliminating of a characteristic of the stimulus figure. It is difficult to see how the introduction of these two categories contributes any positive information as regards the perception and reproduction of forms. The classification is strictly logical and the 'characteristic' which is intensified or diminished depends entirely on the point of view of the experimenter. The observer might have perceived a very different characteristic from that which the experimenter saw, and hence what was sharpening for one might be levelling for the other. For example, suppose that two parts of a figure not quite equal in size are reproduced equal or more nearly equal than they had been. If 'unequal size' be considered the 'characteristic' of the figure, then the change described is levelling. But if 'nearly equal size' be considered the 'characteristic,' then the change is sharpening.

An examination of the forms which Wulf used as stimuli explains why the changes could so easily be divided into two opposite categories. Either by design, or by chance, most of the stimulus figures were of such a nature that they could vary only in two directions. The commonest type of figure used was one in which there was two elements, one element differing somewhat from the other, such as two triangles of different shape having a common base; two connected forms of the

same shape but having a different size, etc. If the two elements in the figure were equalized, this constituted levelling or the suppressing of a characteristic. If the two elements were further differentiated, this constituted sharpening or the exaggerating of a characteristic.

The stimuli used in the present investigation, in contrast to those described above, were single forms and furthermore they were uniformly contour forms. With such as these, there was a wide possibility for variation, or, in other words, changes could take place in a variety of directions. No evidence for two opposite types of change was found. In brief, then, sharpening and levelling are in the first place distinguishable only in a logical sense, and in the second place are due to the peculiar nature of the figures used.

With regard to the secondary classification of Wulf's reproductions, a fairly close counterpart for normalizing can be found in Object Assimilation. As for emphasizing, or the exaggerating of some characteristic of a form owing to particular attention to that characteristic during perception, the change is quite intelligible in the light of the examples which Wulf gives. Most of these examples could be regarded as coming under Verbal Analysis. It is when we come to consider the structurally conditioned change that difficulties arise. Wulf states that the change in a reproduction is here due to the nature of the form (*Struktur*) itself. He is evidently not speaking of the physical form but of the phenomenal, or perhaps the conceptual form.²³ This perceived configuration is regarded as having inherent tendencies to change in a certain direction. The examples which are given of this type of change consist of four reproductions which became wholly or to a greater degree symmetrical, one reproduction in which the angles of a zigzag line became more acute, and one reproduction in which a flat curve connected to a straight line was drawn with a sharper curvature because it had a greater 'weight' than the straight line. In one of the

²³ Just what a conceptual form would be like is difficult to state. Rignano mentions Locke's difficulty in trying to form a concept of triangle and criticizes the configurationists on this score. E. Rignano, The psychological theory of form, *Psychol. Rev.*, 1928, 35, 128-133.

four reproductions which became symmetrical, there had been a 'normalizing apprehension' which would ordinarily have caused a change in the opposite direction had it not been for the stronger influence of the structurally conditioned change. In another, there had been an 'emphasizing apprehension' which likewise would have been expected to cause a change opposite to that of the structurally conditioned change. Apparently, then, this type of change is *independent of the way in which the figure is perceived*.

Precisely how this change comes about is not clear. Wulf states, it is true, that *all* the changes, whether they be sharpening or levelling, are to be explained by the fundamental laws of the *Gestalt*. The most general of these laws is the Law of Pregnancy, which is to the effect that every configuration tends to become as 'good' as possible.²⁴ One is led to infer that the structurally conditioned change, then, is due entirely to this tendency towards a specific, lucid, complete or 'good' *Gestalt*. The configurationist's *form* is apparently something which, in its own right and independent of the experience of the observer, possesses the capacity to change. A configuration is dynamic, and is governed by the laws of its own structure.

The issue is this: Is the change in a reproduction of a perceived form caused by the influence of past perceptions on the perception and memory of that form, or is the change caused by the nature of the form itself? No attempt is made in the present study to settle this issue. There will have to be experimental evidence on the question of whether or not there are forms which, when perceived, always and invariably tend to change in a certain respect, without reference to the way in which the forms were apprehended, the associations which accrued, etc. No evidence for the existence of such forms was found in the present results. The types of change here observed may all be explained, it is believed, by the supposition that the experience of the individual has brought into existence certain habitual modes of perception, and that these perceptual habits, rather than the laws of configurations, condition the changes observed.

B. Persistence of Changes. Wulf particularly emphasizes

²⁴ Wulf, *op. cit.*, 370-373.

two facts in connection with his reproductions, at different times, of the same figure. (As has been stated, his observers first reproduced the stimulus figure 30 seconds after exposure, then after one day, after one week, and sometimes after two or more weeks.) First, a change took the direction either of sharpening or of levelling from the beginning, and this direction was maintained in the later reproductions. The direction of change was reversed in the case of only three series of reproductions. Secondly, a change once started in a certain direction was *continuous* in that direction; in other words, there was consistent progress in the sense of greater sharpening or levelling with each succeeding reproduction.

The interpretation of these two facts, of the unidirectional character of the change and of the continual increase in the amount of change, as evidence for a dynamic *Gestalt* which merely follows the laws of its own nature, is not borne out by the present experiments. It was found that changes did persist, in the sense that a figure which had been apprehended in a certain way and was changed accordingly was remembered in the same way and reproduced with the same change in later reproductions. But the change was never independent of the way the figure had been apprehended. Observer Br in Group I at first perceived Fig. 9, Chart I as similar to Fig. 1, Chart I. His reproductions of Fig. 9 during the first three sittings exhibited pronounced assimilation to Fig. 1. Then for two experimental sittings he either did not notice the figure or forgot it, for no reproductions were made. At the sixth sitting he started reproducing Fig. 9 again with an entirely different sort of change. There was no assimilation whatever to Fig. 1. He stated that it seemed to be an entirely new figure which he had never noticed before.

The dependence of the reproduction on the manner in which the figure was perceived, as illustrated by the fact just mentioned that the same figure apprehended at different times in different ways will lead to widely different reproductions, is not original with this investigation. Wulf emphasizes the importance of the *Auffassung* throughout his paper, and he states in his summary that the direction of change depends

upon this original way in which the figure is apprehended, a particular type of apprehension leading to a particular type of change. With this aspect of Wulf's study the present investigation is in full accord. It is only when he considers the structurally conditioned change and the implications of uni-directional and progressive change during memory that an apparent contradiction arises.

With regard to the progressive nature of Wulf's changes, it was found that for two of the present kinds of change, Object Assimilation and Completion, there was some tendency for the change to become greater, the longer the figure was in memory. A figure which had been apprehended as similar to an object often, but not invariably, was reproduced more and more like the object as time went on. A form grasped as 'electric light bulb' and reproduced with some assimilation to the object was reproduced 6 months later as completely similar to the object, even to the adding of lines inside the figure to represent filaments. Another form apprehended as 'footprint' and slightly changed in that direction, was reproduced 6 months later with the precise shape of a footprint. As for Completion, nearly all the reproductions of broken figures after 6 months showed full attainment of this kind of change, and those remaining showed considerable progress towards it. The interpretation of these facts, however, is not the interpretation which Wulf gives. It seems more plausible to believe that progressive change is due not to the dynamic nature of the configuration but to an *increasing degree of assimilation*.

C. Assimilative Perception. Wulf, it is true, admits²⁶ that a possible explanation for normalizing could be found in Wundt's doctrine of *assimilative perception*. There are evidently factors within the observer which contribute towards determining the perception, in addition to the influence of the stimulus figure itself. It is supposed that these factors are nothing but memories of earlier perceptions. Such memories are aroused by association and *fuse* with the image aroused by the stimulus figure into a single perceptual image. If, then,

²⁶ Wulf, *op. cit.*, 367.

after an interval a reproduction of the figure is required, the assimilation becomes quite evident since the older traces, which fade more slowly than new ones, are present to the exclusion of the new ones.

Wulf, however, rejects this explanation and proposes one more in keeping with the *Gestalt* hypothesis. When a figure is apprehended as similar to a familiar object, it does not mean that an earlier perception or an average of many earlier perceptions is re-aroused. What happens is that the organism, in its response to the stimulus figure, makes use of certain familiar methods (*Verfahrungsweisen*) and configurations (*Strukturen*).²⁶ These configurations have already become stable. A change in the direction of one of these familiar configurations is due to the fact that it controls all of the perceptual data and, being stable, it asserts itself (*sich durchsetzt*) more and more as time goes on.

It does not appear that there is a very radical difference between the two explanations. The notion of an old memory image fusing with a new perception, and the notion of an old configuration asserting itself over a new configuration differ essentially only in the terms used. If an explanation must be advanced for the facts which have been observed, the present trend of psychology would indicate that it can best be put in functional terms. It has been noted that forms change towards objects, towards the verbal descriptions made of the forms, and towards other forms perceived contiguously in time. The first two phenomena might be explained by the hypothesis that new perceptual activity in an observer takes place in terms of old perceptual habits. The third phenomenon would be due to the fact that one train of perceptual activity is modified by another if they overlap in time and if they have any elements or processes in common. 'Assimilation' in perception would then be caused not by a fusion of images, nor yet by the influence of one configuration on another, but by the turning of a new perceptual process into earlier channels of perceptual activity.

²⁶ Wulf, *op. cit.*, 373.

SUMMARY

1. A reproduction of a visually perceived form is frequently changed in the direction of a familiar object if the object has previously been associated with the figure in consciousness.

2. A change in a reproduction is often conditioned by cues from a verbal analysis which was made of the form during perception.

3. A reproduction of one figure is frequently changed in the direction of another figure if the two figures have been previously associated in consciousness.

4. Gaps or breaks in the contour of a figure are either partially or wholly closed up in the reproduction, or else the figure 'falls apart' into separate units.

5. Curved lines are much more apt to be reproduced as straight lines than the reverse.

6. The changes observed in these experiments have not been interpreted as evidence for a single law determining the changes of configurations, but rather as evidence for the existence of perceptual habits which have arisen in the individual during experience. In general, the nature of a change found in the reproduction depends upon the manner in which the figure was apprehended.

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