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A REAPPRAISAL OF THE ROLES OF PAST EXPERIENCE AND INNATE ORGANIZING PROCESSES IN VISUAL PERCEPTION[1]

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Twenty years ago, in his *Principles of Gestalt Psychology*, Kurt Koffka posed the problem of visual perception in the succinct question, "Why do things look as they do?" He took issue with the usual answer that things look as they do because of our past experience with them, arguing that an empiristic theory not only failed to account for many of the facts of visual perception, but, in addition, entailed a number of logical difficulties.

Few of Koffka's arguments have been satisfactorily met; nevertheless, two decades later, a survey would show that his analysis has had little or no impact on the psychological literature dealing with this problem. For example, a widely used textbook states: "With the few possible exceptions provided by primitive organizations, all perceiving is dependent upon past experience—the so-called habit factor" (**45**, p. 410). Moreover, the empiristic theory has re-emerged in the currently popular assumption that perceptions are governed by motivational and affective forces; in this remodeling, however, critical questions involved in an experiential approach to perception continue to be overlooked.

The present paper attempts to reconsider the logic of the central problem and to examine the evidence bearing, in particular, on the question of whether form perception is learned. We shall restrict our discussion to the controversy between theories which emphasize the role of learning (empiristic theory) and the theory which stresses the role of innate organizing processes (which we shall briefly refer to as the organization theory). The concept of organization is, of course, basic to Gestalt psychology. With respect to its relevance for the field of perception, however, it can be evaluated on its own merits quite apart from the validity of other aspects of Gestalt theory, particularly the physiological theories advanced by Gestalt psychologists.

ANALYSIS OF THE TWO THEORETICAL APPROACHES

It is difficult to find a clear, unambiguous statement of an empiristic position; moreover, many writers assume the validity of empiristic hypotheses but do not offer an analysis of basic questions. The formulation of the problem by Ames and his co-workers (the transactional approach) may serve, however, to il-

[1] We take this opportunity to state our indebtedness to Dr. Hans Wallach who has so greatly influenced our approach to the problems discussed in this paper. We also wish to express our gratitude and appreciation to Dr. Evelyn Raskin for her invaluable editorial assistance.

lustrate a modern empiristic theory which has focused on some of the essential issues in the problem of perception.

The transactionalists (**28**) argue that the percept cannot be derived from the retinal image alone, since an infinity of external objects can give rise to the same pattern of stimulation on the retina. For example, a small object nearby and a large object at a greater distance can result in the same sized retinal image; similarly, a circular retinal image may be produced by a circle in the frontal parallel plane or by an ellipse tilted from this plane. Or, once again, a retinal image of a specific intensity may be produced by either a black object in bright illumination or a white object in dim illumination. How then, in view of this equivalence of outer configurations in producing identical retinal images, can the organism "know" which object to see?[2] The answer given to this question is that the explanation is to be sought in the realm of past events; the retinal stimulus pattern must be interpreted in the light of knowledge from the past.

The question of what the organism sees originally—*before* it is able to interpret the retinal pattern—is not raised. It seems clear, however, that an empiristic position of this kind must hold that the initial perceptual experience would be ambiguous—a given image could result in the perception of a small or large object, a black or white object, etc. By means of "purposive action" with respect to the object, we build up "assumptions" which then determine the nature of the present perceptual experience.

Empiricists in the past formulated the problem in a similar way, but instead of speaking about the ambiguity of the stimulus they emphasized the fact that the stimulus is frequently such that it should lead to a percept different from the one which actually occurs. They pointed out, for example, that the shrinking image-size of an object as it moves away from the eye should result in the perception of diminishing size. Size constancy could not, therefore, be explained by the retinal image alone; the latter had to be supplemented or modified by the contributions of previous learning. Moreover, the sense of touch, rather than purposive action, was thought to provide the basis for the learning needed to attain the correct percept (especially, in the case of form perception).

Köhler (**32**) has pointed out that underlying the empiristic concept is the implicit assumption of the existence of a one-to-one correspondence between *local* retinal stimulation and the resulting sensory experience. Any change in the local stimulus, therefore, should result in a corresponding change in the percept. The fact that such a change does not always occur (e.g., perceptual constancies) had to be explained.

The organization theory differs from empiristic theory in its conception of the physiological correlate of the percept. Empiristic theorists have assumed that the percept should

[2] It is true, of course, that a given retinal form may be produced by an "infinity" of external configurations. This statement must, however, be qualified. The same elliptical retinal image can result from an elliptical object in the frontal parallel plane or from a variety of circles at different tilts from this plane, etc., and, in this sense, the retinal image *is* ambiguous. But, under no circumstances, could a retinal ellipse be produced by a rectangular or triangular object. There is a limitation, then, to the ambiguity of the retinal image and, accordingly, there is no need for invoking assumptions to explain why we see a rounded object and not a triangle.

be correlated with the process initiated by the local retinal stimulus. Organization theorists have related the percept to a more comprehensive set of central processes initiated by certain relationships in the stimulus pattern. When the stimulus is defined in relational terms, it is no longer always necessary to consider the retinal image either as inadequate or as ambiguous for the determination of the percept and to invoke past experience as a way out.

The difference between the two theories in this respect can be most clearly illustrated by reference to the problem of achromatic color perception. The empiricist would say that since different intensities of reflected light may give rise to the same percept (an object in different illuminations appears the same color—i.e., brightness constancy) or since the same intensity may give rise to different percepts (a piece of coal in bright illumination and a white paper in shadow which reflect equal amounts of light to the eye), the proximal stimulus is consequently either ambiguous or inadequate.

According to the organization theory, however, what is seen in a particular region of the visual field depends not only on the properties of the retinal image corresponding to this region (the local stimulus) but also on stimulation from adjacent or surrounding areas. Wallach (72) has clearly shown that the stimulus for achromatic surface color is not the absolute intensity of light from region A alone but is the ratio of light intensities from regions A and B. Without changing the intensity from A, the perceived color in A can be made to vary from black to white by changing the intensity from B. The specific neutral color seen will depend on the ratio of the two light intensities.[3]

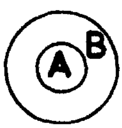

FIG. 1

The assumption of one-to-one correspondence between the local stimulus and perception is therefore invalid. When the stimulus is considered as a relational pattern, it is not ambiguous as the determinant of perceived neutral colors. The coal in bright illumination and the paper in shadow do not give rise to the same *pattern* of retinal excitation. The ratio between the intensity of the object and that of its surround would be different in each case and therefore the perceived colors would differ. Conversely, we can take an object of a particular albedo, place it on a background of some given color and vary the illumination. In spite of the changing amount of light reflected from the object, it will be seen as the same neutral color (brightness constancy) because the ratio of light intensities from the object and its background remains the same. There is, then, no necessity for assuming that the organism has to learn to see the object as black in one case or as white in the other (or as the same color in constancy situations).[4]

[3] Reflection from two surfaces represents the simplest stimulus for neutral color; in everyday life, of course, the stimulus conditions are more complex.

[4] As a matter of fact, careful consideration of Wallach's findings indicates that a learning theory for perceived achromatic color (or for brightness constancy) is impossible. For learning to occur, the organism would have to take into account the illumination in which a particular gray surface is given and to correct for changing illumination. There is, however, no way in which illumination can be registered independently from the surface color; both are given by the same stimulus variable

The same approach is applicable to the problem of size perception. A particular retinal image may correspond either to a large object far away or a smaller object nearby. The stimulus situation is ambiguous only when distance cues are eliminated or are inaccurate. It is, therefore, entirely possible that the underlying correlate for perceived size is the interaction of the area excited in the visual cortex corresponding to the size of the retinal image and the physiological correlate of phenomenal distance (whether the distance cues themselves are learned or not).[5] Such an interaction process may be an outcome of learning but until this can be proven, the alternative of innate organization cannot be ruled out.

In certain cases, however, even when the percept is considered to be based upon stimulus relationships, ambiguity as to what will be perceived still persists. The following example illustrates the point. Suppose we have in a darkroom situation a luminous point *A*, surrounded by a luminous rectangle *B*. Duncker (**14**), in his investigation of the stimulus conditions for phenomenal movement, found that, if the rectangle *B* is slowly moved to the right, point *A* is seen to move to the left, while the rectangle is perceived as stationary. Unless the stimulus situation is defined relationally, one would have to predict that *B* would be seen to move

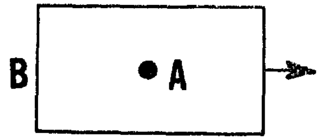

FIG. 2

since only the image of *B* is displaced on the retina. But even if defined in this way, the stimulus condition is still ambiguous, since in physical terms the situation can be correctly described either as *A* being displaced with reference to *B* or *B* in relation to *A*. Thus there are two possibilities; phenomenally, however, one is realized—only point *A* is seen to move.

How is this "preference" to be explained? Early empiristic theory would have maintained that only *B* should appear to move. Transactionalists might argue that initially either or both possibilities could be experienced and we learn to see only the point move, since in real life it is the smaller, surrounded object that usually moves. Carr has offered a similar explanation (**8**).

Duncker believed that seeing point *A* move is a consequence of the operation of a *selective principle* which may be defined as follows: When an object *A* is surrounded by a second object *B*, then no matter which one is actually moving, only the surrounded one will be seen to move, the outer object taking on the character of a frame of reference which tends to be perceived as stationary. So strong is this principle that, even if the surrounded object is the observer himself, he will feel himself to be in movement although objectively it is the surrounding object or scene which is moving (induced motion of the self). According to this viewpoint, the law of surroundedness represents an outcome of innate organizing factors in the

—the amount of light reflected from the object.

[5] Size constancy (defined functionally as a process of interaction of retinal size and perceived distance) should be distinguished from the problem of distance perception per se. Evidence that distance cues are entirely or partly learned would not prove that this interaction process is learned. Conversely, if distance cues are innate, it does not follow that size constancy is innate.

brain and not a product of learning.

It may be useful at this point to summarize the principal features of the organization theory:

1. The percept is considered to be based on stimulus relationships. Some examples of phenomena explicable in terms of relational stimulus conditions in addition to achromatic surface color (ratio of light intensities) and movement (relative displacement) are: phenomenal velocity (rate of figural change [6, 73]); geometrical illusions; chromatic color contrast; and those listed below as illustrating the operation of selective principles.

2. In many cases, it is necessary to assume, in addition to the relational properties of the stimulus, the operation of selective principles according to which sensory data are organized. Thus, one perceptual experience arises rather than another, although, on the basis of stimulus conditions, both are equally possible.[6] Some examples where such principles are assumed to be operating are: laws of grouping (**80**); apparent movement; figure-ground organization (**58**); laws of surroundedness and separation of systems in movement (**14**); sound localization by head movements (**74**); depth based on retinal disparity (**82**); kinetic depth effect (**77**); phenomenal identity (**41**, **69**).[7,8]

3. The further assumption is made that the percept is *innately* determined by such stimulus relationships and selective principles of organization. Lashley has described this position in the following statement:

"The nervous system is not a neutral medium on which learning imposes any form of organization whatever. On the contrary, it has definite predilections for certain forms of organization and imposes these upon the sensory impulses which reach it" (**35**, p. 35).

It is possible for an empiricist to agree with organization theory that the stimulus is a relational affair; in addition, he might even agree to the assumption of selective principles. He would then have to argue that these principles are based upon past experience. These views, however, would represent a radical change from traditional empiristic thinking; there are indications that empiristic theory may now be moving in this direction (**48**, **71**).

The contrast between the two theoretical approaches can be further illustrated by the problem of form perception.

We assume that it is now generally agreed that the relative position of points in the visual field does not have to be learned but is given by the relative position of corresponding points of excitation in area 17 (although at

[6] Some writers, while opposing the empiristic view, do not see any need for a concept of organization. Thus, Gibson (**19**) and also Pratt (**49**) argue that it is sufficient to correlate the stimulus conditions with the resultant percept in accordance with traditional psychophysical method. Gibson has also pointed up the necessity for correlating the percept with more complex aspects of the stimulus. He does not see the need, however, to correlate the percept with the central processes initiated by the stimulus relationships, as does the organization theory. The above examples of selective principles show very clearly that the proximal stimulus itself, however defined, does not contain all that is needed for an explanation of the percept.

[7] It is still too early to tell whether phenomenal casuality as investigated by Michotte (**43**), should be included in the above list.

[8] It does not seem to the authors that the concept of Prägnanz is either clear or helpful in dealing with perceptual phenomena; moreover, there is very little unambiguous evidence to support it. On the other hand, selective principles as described by Wallach do seem to imply some tendency toward preserving constancy in perceptual experience.

one time this was a debated issue). The orderly projection of the retinal points to the visual cortex in such a way as to preserve the same position of points relative to one another (topologically) seems a sufficient condition for the explanation of the perception of visual direction. Walls (**79**) refers to these anatomical facts as an additional argument against an empiristic theory of visual direction. Furthermore, there is evidence against a learning theory for radial direction—i.e., the direction of a point from the observer (see p. 282). A precondition for radial direction must surely involve the perception of correct position of points relative to one another. Consequently, the major unresolved issue in the area of form perception is whether *organization* of the field is a result of learning.

As experienced, the visual field is not a patchwork of various colors and brightnesses but consists of circumscribed units, certain areas belonging together and forming shaped regions which are segregated from other regions. Wertheimer (**80**) emphasized that segregation in the visual field was not a fact to be taken for granted but one which presented a crucial problem in the investigation of perceptual processes. One explanation of this problem has been given in terms of the retinal image. But the explanation that one sees a book because the image of a book stimulates the retina is insufficient. Sometimes one may not see a segregated unit when its image is objectively present (e.g., camouflage) and at other times, one may see a unit where objectively there is none on the retina (e.g., a star constellation). An even more fundamental objection is the fact that, although the retinal image may accurately represent the external situation, in that a homogeneously colored form would give rise to an image having the correct shape and representing the color appropriately,[9] there is no reason why the percept should be correctly organized (i.e., in agreement with the shape and segregation of that form in the external world). The mosaic of stimuli on the retina could be organized in various ways. It is logically possible, for example, to see part of the form together with part of the surrounding area as one unit; the shape of this unit would be determined by the parts which are united.

The tendency to attribute certain aspects of perceptual experience to the retinal stimuli (the view that organized shape is given by the image) has been called by Köhler (**32**) the "experience error." Many empiristic writers, including Ames, do not explicitly deal with the problem of form perception, apparently not realizing that it is a problem. Similarly, S-R theorists generally speak of a form as a stimulus which is given and simply assume that no explanation is necessary. Since, however, the organized percept is not directly given by the retinal image, a theory is needed to explain the perception of forms.

The "correct" organization can be explained in two ways. Empiristic theories assume that the sensory data are structured only as a result of learning. According to this view, a young child or animal would initially not experience a visual field with segregated objects. Instead, it would see a mosaic of different brightnesses and colors (or perhaps an *incorrectly* segregated field). Murphy (**46**), for example, states that the infant has to learn to sort out his impressions and to learn that certain stimuli go with

[9] We are limiting our discussion to two-dimensional forms presented in the frontal parallel plane.

others. From the initial blur, there gradually emerges a segregated visual object.

The alternative explanation argues that the sensory impulses are structured according to selective principles of organization which do not depend on learning. Such selective principles were first described by Max Wertheimer (**80**), who referred to them as laws of grouping. Using line and dot patterns, he demonstrated that grouping was not a random arbitrary affair but occurred according to definite principles such as proximity, similarity of color and size, good continuation, etc. Wertheimer described and illustrated these principles with dots and lines but he did not in any way imply that grouping factors operate only with such stimuli. These factors are intended as an explanation for object and form perception in general. Perhaps not all of these factors are necessary to explain organization. Some may, as a matter of fact, prove to be incorrect; nevertheless, organizing factors of this kind seem indispensable for the explanation of form perception. The following illustration demonstrates how these principles would operate to account for the perception of a black circle on a white background.

1. Within the circular contour of the retinal image of the black circle, all points are similar in color as are the points outside the contour (grouping by similarity of color).

2. Within the contour, all points are nearer to each other than to points outside the figure with the exception of points on the contour (grouping by proximity). The following diagram illustrates how this factor would work:

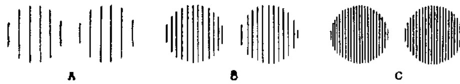

FIG. 3

In A one sees two constellations of lines each because of proximity. In B the two constellations are even further unified and segregated from each other. In C the grouping is still better and now we have two distinct forms as in everyday life (modified from Köhler [**30**]).

Thus, similarity and proximity explain why the points within the contour are grouped together and separately from the points outside the contour. As already noted, it is often not realized that if the retinal image is an unstructured mosaic of stimulation, there is no reason why points within a contour should not be seen as belonging with points outside the contour. That they are not is precisely what calls for explanation.

3. The principles of proximity and similarity are insufficient to explain why the circle instead of the surrounding area appears as a shaped entity. To account for this fact, we must invoke another principle of organization first described by Rubin (**58**). Physically, a contour line serves as a boundary for two areas; it, therefore, can be described as belonging to both. Phenomenally, however, the contour belongs to only one area, giving shape to that area which thereby becomes the figure. The other area remains shapeless and is seen as the ground. This biased belonging of contour must be due to a selective principle—figure-ground organization.[10]

[10] In those cases where conditions are ambiguous, the figure-ground organization is labile and easily reverses itself. The phenomenon of reversible figures in general (i.e., including other types such as the Necker cube and the Schroeder staircase) again shows very clearly that the retinal stimulus does not contain all that is needed for an explanation of the percept.

In the above example, the contour belongs to the black area (because the surrounded region is favored in figure-ground organization), thereby giving rise to the percept of a black circle on a white ground. Most instances of two-dimensional form perception would seem to be accounted for by these laws of grouping (proximity and similarity) and the biased belonging of the contour (figure-ground).

The principles of organization can be considered as purely descriptive generalizations. One can employ these principles without invoking any theory of brain function; nor would any particular type of brain model be demanded. More specifically, the value of the grouping factors as explanatory concepts for form perception does not depend on the physiological theory developed by Köhler in connection with figural aftereffects (**34**). This theory is designed to deal with the question of how the cortical pattern of excitation is related to the phenomenal size and shape of the percept. By relating the percept to *functional* distance in the cortex (i.e., degree of interaction of current fields) rather than to geometrical distance, and by treating satiation as a changed resistance of the medium to interaction, Köhler was able to account for the facts of figural aftereffects. But even if this theory is correct, it does not eliminate the need for grouping principles, about which it says nothing.[11]

In the present paper, we have limited the discussion of form perception to the problem of organization. In doing so we simply assume that the relative position of points to one another in the visual cortex corresponds very closely with the relative position of points in the perceived scene, thus avoiding for the present the question of whether some theory of functional distance is also necessary. Moreover, no attempt is made here to explain why the distortions of the retinal pattern which occur in its cortical projection do not lead to distortions in perception.

An additional problem in form perception arises in connection with whole (Gestalt) qualities and with the fact of transposition (i.e., the phenomenal equivalence of form transposed in size, color, position, etc.). There must be some aspect of organization which underlies the whole quality and which distinguishes one form from another. Underlying the perception of a circle, for example, there must be some characteristic pattern of interaction (one might speculate that it would be symmetrical in some way). This pattern yields the whole quality of circularity, which can also be produced by other patterns of the same form but of a different size or color, since the same characteristic interaction occurs in each case. Although this problem has not been solved, the fact of whole qualities and their transposability represents one of the strongest arguments for the existence of spontaneous processes of organization.

Hebb (**23**) has outlined an empiristic theory of form perception directed toward answering the major

[11] Recently, however, Köhler has suggested that the flow of direct current which he has found to accompany perception may also explain why the figure appears as segregated and distinct from the ground. The current within the cortical correlate of the figure is considered to be highly concentrated and sharply segregated from that of the ground (**33**). Whether or not this particular idea is correct, it must be admitted that some physiological theory could also adequately explain grouping. The important consideration is that *some* unlearned law of grouping is necessary, whether stated in purely descriptive terms or in terms of brain events.

arguments of Gestalt theory, many of which are recapitulated in this paper. Space prevents a detailed analysis of Hebb's theory, although much of the evidence he cites is evaluated below. Hebb is not primarily concerned with phenomenal facts in perception but rather with the problem of explaining the *response* to stimulation. Consequently, he discusses only some of the problems considered here.

Hebb grants that a form has "primitive unity" (Hebb's term for figure-ground organization) prior to learning but (if we understand him correctly) this unity does not suffice for form perception. The authors find this point difficult to grasp. Would not the primitive unity of an extended figure (e.g., a straight line) be phenomenally different from that of a compact one (e.g., a solid-color circle)? If so, the admission of primitive unity implies that form perception is not learned. Figure-ground organization means that the contour belongs to the figure, thereby giving it *shape.* Moreover, Hebb does not make clear how the emergence of "cell assemblies" (integrated networks of excitation in the visual areas) changes the phenomenal experience of a form in any way beyond its primitive unity.

Hebb believes that many facts of memory suggest that the memory trace must entail a structural (i.e., physical) change in a specific locus in the brain (a conclusion which he erroneously believes is denied by Gestalt theory) (**23**, p. 12 ff.). His concept of cell assembly as a particular kind of neural change in a specific locus, characteristic of the stimulus, is intended to explain recognition, i.e., how the same response can be made to a transposed form. Presumably a multiplicity of such assemblies for a given stimulus-pattern are established in all possible positions and to each the same response is associated. To us, however, transposition suggests that the essential correlate of phenomenal shape is the process to which the stimulus gives rise and not the place in the cortex where it occurs. But this does not imply that the memory trace is unlocalized. Actually, those sympathetic to the organization theory have often speculated that the trace may be localized and recently some evidence for trace localization has been reported (**76**). They merely stress the fact that, for recognition to occur, a later perceptual process need not occur in the same place as the trace.

Confusion arises when "appearance" is made synonymous with "response."[12] Eventually, of course, a theory is needed to explain how stimulation of different cortical cells can result in the same motor response. The authors believe, however, that premature preoccupation with this problem has led behavioristic psychologists in the wrong direction.[13] It is possible for two similar forms (projected to different loci in the visual areas) to look alike because of similar cortical processes prior to the development of motor responses. Later on, motor development makes possible the association of a specific response (on the human level, the appropriate word) to these similar percepts.

Logical Difficulties Inherent in the Empiristic View of Form Perception

The statement that the organization of the visual field into shaped regions is learned must mean that at an

[12] The widespread use of the term "perceptual response" is a clear illustration of this identification.

[13] For a lucid discussion of the necessity to deal with phenomenal data in perception, see Allport (**2**, Chap. 2).

early period in the life history of an organism the visual world does not consist of segregated and unified objects, but appears instead as a mosaic of sense impressions. In some way learning and experience must then transform the sensory data into shaped visual areas. One argument in support of this position is that our visual field contains segregated forms because of previous experience *with those particular forms*. This of course implies that memory traces of previous percepts play a causal role, i.e., they serve to bring about the emergence of those forms when the same stimulus situation occurs later. But how can a memory trace left by an unorganized mass of sensory data create a shaped visual object in the present field? If the initial perceptions consist of amorphous sensations, then how can the memory of such perceptions organize subsequent processes? Instead of trying to explain how the shaped object arises for the first time out of the chaos of sensation, it would seem much simpler to admit some degree of visual segregation resulting from innate organizing processes. One might then say that the influence of past experience must be secondary to spontaneous organization. This logical difficulty inherent in the empiristic theory can be expressed by asking, "How can we learn to see, if we must see in order to learn?"

Empiricists in the past maintained that organization does not first arise in vision but comes about through the sense of touch. By means of tactual exploration of the environment, the child presumably becomes aware of forms and in some way the tactual form causes segregation in the visual field as well. As Köhler has pointed out (**32**), however, this argument merely transfers the problem of organization from the visual modality to that of touch. It is still necessary to explain how the discrete tactile sensations can yield an experience of a single object. Moreover, it is difficult to understand how the tactile experience can be transformed into a shaped *visual* object and why there should be such excellent correspondence between the two. Nor is there adequate evidence that touch can yield the precision which we have in visual form perception.

These criticisms also apply to the concept of purposive action as a creative agent of the percept. The transactionalists have not explained how the results of action (which must themselves be perceived) determine the nature of subsequent perception.

A more sophisticated argument for the empiristic theory of form perception might be made by assuming that the principles of grouping are learned (cf. **48**, p. 215). This would allow for the transfer of effects of experience to the perception of novel forms; the earlier argument cited above would not, and is, therefore, of limited value. For example, perhaps the child learns that adjacent and similar stimulus elements belong to one object. Even if this is granted, it is still necessary to account for the first emergence of a visual unit. How does the child learn that these stimuli belong together? Does such learning occur because the child sees the object move as a whole when it is manipulated? If so, then "moving together" (Wertheimer's law of common fate) is implicitly accepted as an *unlearned* organizing principle. At some point, the assumption of innate organizing principles must be made in order to explain how learning itself is possible.

Another logical difficulty involved in the effort to explain how specific past experience modifies subsequent perception relates to the problem of trace *selection*. Even if it were assumed that previous learning has resulted in an organized memory trace for a particular form, this trace cannot exert an influence when the same stimulus is presented again unless this trace and no other is aroused. One way in which the trace of a previous percept could be aroused and thus influence the unorganized sensory impulses would be for the latter to travel to the locus in the nervous system where the relevant trace is "stored." Contact in this way might occur if the successive images of a given object always occurred in the same place on the retina, but this is rarely, if ever, the case. Consequently, as Köhler has argued in elaboration of a point made by Höffding many years ago, appropriate trace arousal must depend on some kind of similarity between the present perceptual process and the trace left by the previous process (**31**). This means that the present perceptual process must be organized *before* it can communicate with the trace, because only an organized process (i.e., resulting in a definite shape in the case of form perception) can be similar to the trace representing the previously seen form. If the sensory stimuli are unorganized, it is difficult to understand how the proper trace can be selected from the multitude of traces existing in the nervous system. In general, then, past experience cannot exert any influence until the sensory processes themselves are organized.[14]

The Distinction Between Perception and Related Psychological Processes

The term perception has suffered an extension of meaning so broad as to include almost every psychological process. For example, an experiment (**7**) which obviously deals with recall—the subjects having to reproduce previously seen figures from memory—is widely cited as an experiment in perception. Certain distinctions must be made, not to serve a theoretical bias, but in order to understand the particular process and its relation to other psychological functions.

Perception should, first of all, be differentiated from recognition. Recognition implies a feeling of familiarity—I experience the present object as something I have seen before. The first time the object was seen, however, the perceptual experience occurred without the element of familiarity. In terms of underlying functions, recognition implies that the memory trace of the object is aroused by the present perceptual process; activation of the trace is the basis for the experienced familiarity. By definition, therefore, recognition *is* dependent upon past experience.

One implication of this distinction is that even if the *same* form were presented repeatedly, the same perceptual experience could conceivably occur each time without recognition.

[14] The same argument arises in connection with experiments purporting to show an influence of motivation on form perception. If a motive is to affect a percept, it would have to do so via memory traces of need-related objects. In one experiment (**59**), for example, two profiles (one of which has been rewarded in training sessions and the other punished) are presented together to form an ambiguous figure-ground pattern. If the subject is to see the rewarded rather than the punished profile, the memory trace of the former must be the one which has the greater influence. But how can this trace be selected *prior* to the occurrence of figure-ground organization when presumably no shape is as yet seen which is similar to the rewarded or punished face? (For a further discussion of this problem, see references **57** and **75**.)

This point may be clarified by reference to an imaginary experiment: *S* views a figure and describes it. Let us assume that the memory trace for this form is destroyed. Later the figure is presented again and *S* is asked to describe it. He is likely to give the same description as he did on the first presentation, even though he is not aware of having seen the figure before. The experience is the same because the stimulus gives rise to the same process in the brain. Recognition represents an additional step—the arousal of the appropriate trace.[15]

As stated above, it seems necessary to assume that trace contact and arousal are mediated by the similarity of the present perceptual process to the trace left by a previous visual experience of the particular object (although there is no explanation available at the present time as to how such a process of trace contact can occur). Even if the present percept is changed or attenuated to some extent, trace contact can still occur as long as there is some formal or structural similarity between the percept and trace. This means that recognition can occur even when material is exposed under unfavorable perceptual conditions (e.g., tachistoscopic presentation, peripheral vision, or dim illumination); moreover, it is reasonable to suppose that it will occur more readily in the case of frequently experienced forms (cf. reference no. **24** and the recent work on the tachistoscopic recognition of words [**67**]). Recognition of the material does not mean, however, that the percept qua form is affected. For example, a nearsighted person may recognize a friend from a distance but the recognition does not make the percept any clearer; his visual experience is still fuzzy and blurred.[16]

Closely related to the quality of familiarity is the distinctiveness or "identifiability" of certain forms which comes about only with repeated experience. Hebb points out, for example, that, at first, all chimpanzees look alike; with continued observation one begins to recognize individual animals (a similar fact concerning difficulty in distinguishing faces of members of a different racial group from one's own has been mentioned by social psychologists). Frequently, differences among similar objects are not phenomenally registered in initial perceptions; with greater experience, these differences become manifest. This seems to be true, however, only for complex forms. There is no evidence that recurrent observation is necessary in order for a circle and a triangle, for example, to appear as distinct forms. The problem of the discriminability of similar complex patterns requires further investigation,[17] but it should not be confused with the question of form perception per se. Past experience *is* involved in the former case:

[15] The same point applies as well to a *transposed* form. Gestalt psychologists often stressed the recognizability of a transposed structure, such as a melody. But even if not recognized upon repeated hearings, the melody may give rise to a similar experience each time.

[16] A recent experiment by Engel (**15**) on binocular rivalry between an upright and an inverted face may be another instance where a recognition effect is considered to be a perceptual one. The subjects in this experiment are reported as having seen the upright face more frequently. This result may mean that out of the array of superimposed stimuli, they more readily recognized an upright rather than an inverted face. In our opinion, there is as yet no conclusive evidence that the stimulus elements of the inverted face are *suppressed.*

[17] Gibson and Gibson (**20**) have recently performed an interesting experiment to explore this process, which they call "perceptual learning."

repeated perceptions of the form may serve to strengthen memory traces of the details and of the relation of parts to the over-all pattern. These traces provide the basis for an increased awareness both of the internal structure of the form and its difference from similar patterns.

It is also essential to distinguish perception from interpretation. A good deal of the evidence concerning the effects of past experience or motivation on perception actually refers to the process of interpretation. Form perception has been defined as the experience of a segregated object of a certain shape in the visual field; interpretation, on the other hand, refers to the meaning which the visual form has for the subject. Unlike form, meaning is not an outcome of the present stimulus pattern; meaning consists of those qualities and properties acquired by an object through association and learning. On the functional level, meaning derives from the memory traces which are associated with the trace of the visual form itself (e.g., a hammer has meaning because on previous occasions we have seen this particular form used in a certain way; this use is preserved in traces which are associated with the trace of the form percept.)[18] This distinction is difficult to make clear because, phenomenally, we perceive meaningful objects; usually, we do not first experience a pure form percept and then become aware of its meaning. On the level of experience, the meaning is given in the percept, but functionally, two processes must be distinguished.[19]

In some sense modalities, the distinction we are making does frequently appear in experience; e.g., I hear a sound and then try to identify it—the cry of a baby or meow of a cat. Even in vision the separation of processes may be experienced. For example, a nonsense form is seen as a segregated unit of a certain shape; nevertheless, it may have little or no meaning, and one may strive to interpret it. (Moreover, after gaining meaning, the form itself does not change in my experience. At first, ♪ was a meaningless shape. Although I now see it as an eighth-note the visual form has not altered in any way.) The separation of processes may be more evident in the child's experience than in the adult's. It seems probable that the child sees objects before he has any concept of their meaning.

The separation of the perceptual from the interpretive process is not an arbitary matter of definition; on the contrary, it is necessary to make this distinction in order to account for the nature of our experience. It is important also to keep this distinction in mind when evaluating experimental studies of perceptual problems. For example, if we should want to describe correctly the initial perceptions of congenitally blind subjects whose vision had been restored,

[18] There has been some confusion concerning the treatment of meaning in Gestalt psychology. Apparently, some of the earlier writings of Gestalt psychologists created the impression that meaning was thought to be given directly in the present percept. (The contact between Gestalt psychology and philosophical phenomenology may have contributed to this impression.) It seems to the present writers that meaning must be explained in terms of associated traces or trace systems, and is, therefore, derived from past experience. Köhler has stated this position very clearly (**32**, p. 138 ff.).

[19] The same is true about the distinction between perception and recognition. Phenomenally, familiarity is in the object; functionally, one must assume that familiarity derives from trace reference *after* the perceptual process occurs.

we should not confuse their failure to identify objects with an inability to perceive objects as segregated units. Much of the data collected by von Senden (**61**) is vitiated because the investigators did not clearly distinguish the two functions. We may be distorting the experience of a hungry subject who describes an ambiguous shape as a steak if we conclude that the hunger drive has affected his perception (cf. **39**). Possibly, he sees the same form as does the nonhungry subject, but interprets it differently. (If asked to copy the form, both subjects might make fairly identical drawings.)

The Rorschach test, insofar as it is concerned with the ways in which shapes are described (leaving aside the color, shading, and other aspects), is primarily a test of interpretation. Many meanings can be ascribed to the blot as a whole or to a particular part.

Experimental Evidence

The major portion of the following section will be devoted to a critical analysis of some representative studies dealing with the question of whether form perception is innately determined. To begin with, some evidence relating to the determinants of other perceptual processes will be briefly cited but there is no intention of making a comprehensive coverage of the literature bearing on this issue. Many studies are inconclusive because no attempt was made to control the effects of previous experience.

Visual direction. Schlodtmann (**60**) showed that congenitally blind subjects localized the direction of pressure phosphenes in the same way as do normally sighted subjects. More recently, Hess (**26**) has confirmed earlier findings (e.g., **4**, **11**) that chicks peck in directions innately determined by retinal locus. Sperry's experiments (**68**) provide further support of the thesis that visual direction is unlearned.[20]

Visual constancies. The constancies—size, color, and brightness—have been shown to exist in various animal species (cf. reference no. **40** for a summary of the literature). Size constancy, for example, has been demonstrated in a three-month-old chicken (**22**) and in eleven-month-old infants (**17**). Although these studies are not crucial for the issue of innateness, they would appear to conflict with naive empiristic views which account for constancy on the basis of knowledge or unconscious inference.

Depth perception. There seems to be little unequivocal evidence relating to the problem of distance or depth perception. Lashley and Russell (**36**) concluded that visual depth was innately determined in rats, and Hess succeeded in showing that chickens with no previous visual experience (or with prior alternating monocular vision) utilized binocular depth cues (**26**).

Visual reflexes. Observations on infants reveal that some visual-motor coordinations, such as eyelid responses to intense light, pursuit movements, and fixation are present at birth, or soon after (**12**, **50**). These data, however, are not entirely relevant to the study of visual experience, since they may simply represent reflex responses to stimulation by light without being accompanied by the perception of direction, color, form, or depth.

Form. Two major experimental approaches have been employed to determine the effects of past experience on form perception. The first group of studies we shall discuss attempts

[20] Caution is necessary in generalizing the results of animal experimentation, in perception as well as other areas, to the human level.

to show how experimentally created familiarity with specific forms affects subsequent perception; the second group attacks the problem more directly by studying the consequences of the deprivation of normal visual stimulation soon after birth on later perceptual development. Included in the latter approach are the observations on congenitally blind humans who gained vision in later life.

The classic experiment in the first group is the investigation by Gottschaldt (**21**). Gottschaldt wanted to show that a novel geometrical figure will be seen in accordance with the laws of grouping rather than past experience. He reasoned that if form perception were determined exclusively by experiential factors, a complex figure *b*, containing a simple form *a* which has been seen very frequently in the past, should be perceived as the familiar unit *a* plus other parts. Gottschaldt designed some simple outline figures which were presented repeatedly to subjects for memorization. Later, complex figures in which the *a* figures were embedded were shown and the subjects were instructed to describe them. It was found that only in a negligible number of cases was *b* spontaneously described as the *a* figure and additional lines. Despite its great familiarity at the time of the test, *a* was not seen.

Gottschaldt's experiment has been criticized on the ground that it merely shows that familiar units can be camouflaged by embedding them in larger contexts. This criticism misses the point completely because it fails to see the necessity for explaining why the physically present figure is phenomenally absent. The camouflage is successful because of the victory of grouping factors over past experience. Not just any additional lines will successfully camouflage the *a* figure but only those which, because of the laws of grouping, produce new and compelling organizations. A few well-placed lines will achieve this effect, whereas a complex array of lines may not succeed in camouflaging the *a* figure (cf. **32**, p. 193 ff.). Good continuation is probably the strongest factor in Gottschaldt's figures. Camouflage in nature, which of course involves additional factors (e.g., countershading, similarity of color, etc.), also demonstrates that familiar objects will not be readily perceived when they are in certain environmental backgrounds (**10**, **42**).

According to Hebb, Gottschaldt's conclusion "is valid only if the total figure is an unanalyzable whole, which it surely is not" (**23**, p. 24). One *b* diagram, for example, contained two parallelograms and a set of lines forming a Z. Hebb implies that the presence of these familiar units in the *b* figure explains why the *a* figure was not seen. It is possible, however, to embed the *a* figure in a *b* diagram which contains familiar

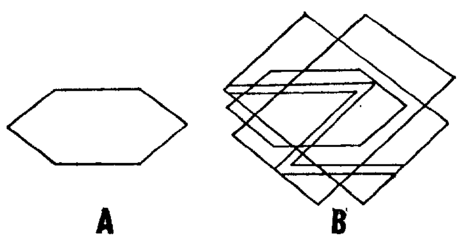

FIG. 4. *A*. ONE OF GOTTSCHALDT'S SIMPLE FIGURES; *B*. A MODIFIED VERSION OF GOTTSCHALDT'S COMPLEX FIGURE CONTAINING "A," TO WHICH HEBB REFERS

parts and still the simple form will stand out. It is the structure of the total figure which is crucial and not the familiarity of any of its parts. Moreover, even if the subject distinguishes such familiar parts in the complex diagram, the question still remains whether this is due to familiarity or to structure.[21]

According to some critics (**28**), Gottschaldt's thesis cannot be accepted because it has been refuted by later investigators. The experiment by Djang (**13**) is often cited in this connection.

Djang's results show a strong effect of past experience. Simple figures which had previously been learned were found in complex forms twenty times more frequently than those not seen before. (All figures were composed of dotted lines; the subjects had to learn to draw the figure correctly from immediate memory and to associate a nonsense name to each figure. The task was described as one of learning and memory.)

Careful examination of the conditions of Djang's study makes it apparent that her results do not invalidate or even challenge Gottschaldt's conclusions. Of special significance are the following aspects of the experiment.

1. The instructions encouraged the subject to break up the complex figure into individual sections or units. "Try at once to reproduce . . . what you have seen . . . . Indicate by the additional use of the yellow pencil the individual units or sections into which you split up the figure" (**13**, p. 34). Evidence for seeing the simple figure in the complex one was based on the units which the subjects encircled. The complex figure contained many subunits so that, in addition to seeing the figure as a whole, the subject with this set might be expected to see now one part and now another as a relatively separate entity. When the subject recognizes a unit as one he has previously seen, he is likely to encircle it. This would facilitate the learning of the complex figure, since the subunit represents a substantial portion of the total figure. That such a set was important is shown by the author's remark that "success in finding the simple figure in the camouflage seems to bear a relation to the amount of interest displayed" (p. 47). Enthusiastic subjects were the most successful. Djang does show that her data cannot be explained merely as a result of a set to look for familiar units. But a set to break up the figures into parts is an important condition for the effect.

2. Unlike Gottschaldt's simple figures which were absorbed into the larger structure, many of Djang's are isolable subunits because their contours are not destroyed by good continuation. Since the camouflaging effect of Gottschaldt's figures is an essential feature of his design, one may question the construction of Djang's figures. Her results which are based on the use of these figures can, therefore, in no way affect the validity of Gottschaldt's conclusions.

3. Even without an analytical set, the subjects in this experiment might take note of a simple form in a complex one because they *recognize* it; this is true because of the point made in paragraph 2 above. In Gottschaldt's experiment, the *a* figure was not recognized because it was not seen. In Djang's study, however, both the simple unit which had not been seen in prior exposures and the one which is recognized may have been perceived (if only briefly) in the complex figure with equal frequency; but if the subjects had not seen the simple unit before, there would be no special reason to notice it. In other words,

[21] Hebb also points out that if one looks for the simple form, one can find it. Here, of course, he is referring to the problem of the influence of attention or set and we agree that no psychological theory has as yet provided a satisfactory answer to this problem.

Djang has not proved that there is a difference in frequency of *perception* of the simple form but only that there is a difference in the *utilization* of this form based on recognition.

4. The fact that some masked figures were more easily found than others cannot be explained by previous experience (which was equal for all simple forms) but must be understood on the basis of factors of organization. Those masked figures whose contours do not continue into the other lines of the complex form should be readily seen; on the other hand, the use of good continuation should lead to fewer successes. Figures LAJ, ZIF, and GIW have the least number of successes—in these figures the contour of the simple form is to some extent continued into the larger structure. The influence of past experience is greatest with figures XEH, QOW, POQ, KOJ—and these are the simple forms which are easily segregated from the larger form. It is possible to take one of Djang's figures and, by strengthening organizational factors, make it difficult for the familiar simple figure to emerge (see Fig. 5).

This shows conclusively that it is not the use of dot figures which distinguishes Djang's experiment from that of Gottschaldt. It is the construction of the dot figures, together with her procedure, which made her results possible. As a matter of fact, this experiment supports Gottschaldt's contention that strong structural factors overcome the effects of familiarity.

Braly (5) attempted to show that the perception of polygonal, dot figures is influenced by the kind of figures shown earlier. The test slides, however, contain several of these dot figures and it is impossible to see all of them clearly in the very brief exposure time. The experiment demonstrates only that given a set to perceive a certain form and subsequently given inadequate perceptual conditions, *S*s will tend to guess in accordance with that set.

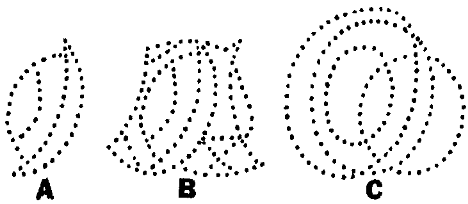

FIG. 5. *A*. ONE OF DJANG'S SIMPLE FIGURES (QEW). *B*. DJANG'S COMPLEX FIGURE CONTAINING QEW (KOJ). *C*. A MODIFIED VERSION OF KOJ CONTAINING QEW

Henle (24) posed the question whether a familiar form would be more readily perceived than an unfamiliar one when structure is held constant. A series of letters and numbers and their mirror reversals (together with obverse and reverse nonsense forms) was exposed peripherally or tachistoscopically. The results, based on the *S*s' reproduction of the forms, show that the obverse letters were reproduced correctly more frequently than the reverse letters. Does the experiment demonstrate an influence of familiarity on *perception?* Perhaps the obverse letters are not more clearly perceived than their mirror reversals, but are more easily recognized under difficult perceptual conditions because of their familiarity. Once recognized, a familiar letter is easy to draw. The reverse letter would probably be seen as a nonsense figure, and, consequently, the subject is faced with the added difficulty of remembering its inadequately perceived shape in order to draw it a few moments later. Following the analysis given above, we would argue that the presence of stronger trace systems for obverse letters allows recognition to occur more readily.

In his investigation of figure-ground organization, Rubin (**58**) found that *S*s who were instructed to see one part of an ambiguous form as figure (the other part then appearing as ground), would subsequently tend to see the same part as figure. If Rubin's results were valid, they would certainly provide evidence that memory traces can organize perceptual processes. Recently, however, a careful repetition of Rubin's experiment by Rock and Kremen (**57**) failed to demonstrate this effect.

Leeper (**38**) found that subjects would generally see Street figures as meaningless collections of fragments upon first presentation. After a brief period of observation (sometimes accompanied by verbal hints from the experimenter), the figures were reorganized and perceived as meaningful objects. Several weeks later, when the same Street figures were exposed tachistoscopically, they were immediately recognized in their meaningful form. Leeper's experiment does show a past experience effect, and thus seems to contradict the logical argument that traces cannot influence perceptual processes until the latter are organized. This specific problem will be discussed below.

We turn now to a consideration of the more direct kind of evidence. It would appear that a crucial test of the empiristic and organization theories could be provided by a "deprivation" experiment in which no opportunity to learn form perception through visual experience is permitted during the organism's early life.

On the human level, the data consist of observations made on cases of congenital blindness (due to cataracts) to whom vision was restored in later life by surgical operation. The literature on such cases has been analyzed by von Senden (**61**) and his study is often cited in support of the empiristic theory. According to Hebb, for example, these patients could not immediately distinguish forms after vision was gained; a long, gradual, learning process was necessary to enable the patients to perceive. There are, however, serious deficiencies in this evidence (cf. Michael Wertheimer [**81**], who describes some of the flaws and, in addition, observes that von Senden has often been cited erroneously). The conditions and the exact time after operation of the observations were not adequately described; the extent of vision present before operation varied from case to case; some of the cases were young children whose reports are difficult to evaluate. Moreover, the patients, after operation, were faced with a strange new world and often the investigator (usually the surgeon) did not know what questions to ask, or what tests to perform, in order to elicit the subject's experience. In one case, for example, the patient "had great difficulty in describing her sensations in such a way as to convey any clear conception of them to another" (**37**, p. 148). Much of this evidence, therefore, is inconclusive.

With respect to form perception, it appears that no distinction was made in these studies between perceptual and interpretive processes. In the eighteenth and nineteenth centuries (when most of the cases studied by von Senden occurred) the problem was posed by investigators in the following way: Would a blind person, who can distinguish a sphere from a cube by means of touch, be able to identify these forms visually when seen for the first time? Observations of these newly sighted patients seemed to show that they could not. There is, however, no reason to expect such a result. The patient might see the sphere and cube as different forms but would not know their appropriate names until permitted the use of touch. Moreover, even if told which was which, he would have to remember this information, so that further learning would be required for correct identification, although not for perceptual discrimination.

It is clear from some of these cases that the visual field of the patient was not an undifferentiated blur but did consist of forms and shapes which could be perceived but, of course, not named. Frequently, the case report describes the patient looking at something and asking "what is that?" One intelligent patient, as a matter of fact, was able to identify a ball as round and a toy brick as square upon first presentation (**37**). In a more recent case (**16**), the report also suggests that the patient could see objects but was not able to identify them. The observations on newly sighted patients, therefore, in no way lend support to an empiristic theory of form perception.

More carefully controlled observations are, of course, possible with animals. In recent years, there have been a number of investigations of the effects of early visual deprivation upon subsequent perceptual behavior.

Siegel (**63**), in a carefully designed experiment, raised a group of ring doves with plastic head covers which permitted light stimulation but no pattern vision. The hoods were put into place soon after the birds were hatched and were worn for a period of from eight to twelve weeks. A control group of birds was raised in a normal visual environment. At the end of this pretraining period, window openings were cut in the hoods of the experimental doves. Both groups were now trained on a visual form discrimination—jumping to a triangle vs. a circle. Thirty trials were given on each training day. The criterion for successful discrimination was nine out of ten consecutive jumps to the positive stimulus on any given day of the training series.

Siegel found that the hood-reared birds required an average of 126.8 trials to reach the criterion, while the controls required 77.7 trials; the difference between the groups was statistically significant. These results, according to Siegel, tend to verify theories which stress the crucial role of past experience in perception. Actually, they may be interpreted as furnishing cogent evidence for a non-learning position. If form perception must be learned, it is very surprising that after eight to twelve weeks of homogeneous light stimulation the experimental birds required only 49.1 additional trials for correct performance (one and two-thirds additional training days). Moreover, Siegel's published report gives only group data; the individual performance records (**65**) show that one or two hood-reared birds were able to respond correctly very soon after unhooding. For example, experimental bird no. 13 required only 58 trials to reach the criterion; this performance is better than that of eleven out of twelve controls and practically on a par with the best of the controls (no. 26) who required 50 trials. It must also be pointed out that the group difference obtained by Siegel refers to the arbitrary criterion for success of nine out of ten correct trials. But eight out of ten correct jumps (or even seven of ten) for two or more blocks of ten in succession is certainly above chance performance. We do not know whether a significant difference would be obtained for this criterion.

It must be remembered that form discrimination is not a test of perception alone; cognitive factors are also involved. It is possible that the animal perceptually distinguishes the triangle and circle but requires training in order to learn that response to one stimulus is followed by reward. It might take a human subject two or three trials before he realizes that he must respond to a triangle and not to a circle. Would anyone argue from this fact that on these first few trials the subject did not see two different forms? It is not surprising that an animal deprived of visual form experience for the first several months of life would show some retardation in solving a discrimination problem. (We are not referring to any difficulty in motor performance; no objection to the experiment on such grounds seems justified since Siegel took the precaution of forcing the animals to jump from a platform a total of four hundred times before the hoods were removed.)

An interesting experiment by Miller (**44**) is relevant for the interpretation of visual deprivation studies such as those of Siegel and Riesen. Miller's hypothesis was that the first visual experience of an animal raised in darkness may create "a negative disturbance effect which inhibits instantaneous utilization of the new cues even though perception may be immediate and accurate" (**44**, p. 224). He raised a group of rats in a light-proof cage and a control group in a normal visual environment. At sixty-five days of age both groups were trained to run an obstacle course *in the dark.* (After each trial the experimental animals were returned to their dark cages.) When both groups had learned to perform rapidly, the lights were turned on for the run. The controls did not seem to be affected by the light. The experimental rats, for whom this was the first visual experience, showed a significantly longer mean running time, and an increase of inter-rat variability (individual running times ranged from six to twenty-nine seconds). The experiment shows that performance on a task already learned on the basis of other sensory cues may be disturbed by the new visual experience. Therefore it is probable that such a disturbance would be present in the learning of new tasks, as in Siegel's experiment. In addition, Miller's results point up the importance of taking individual differences into account in studies of this kind.

The *earlier* work of Riesen (**51**, **52**), in which chimpanzees were raised for a long period of time in total darkness, requires only brief mention for the purposes of this paper. The visual defects shown by these animals may have been due to optic atrophy rather than to the lack of opportunity for learning (**79**). The more recent investigations (**53**), on the other hand, are very important for the problem of learning in perception.

In the revised procedure, chimpanzees were placed in a dark room five days after birth. For 90 minutes each day, the animal's head was enclosed in a Plexiglas dome which permitted stimulation by diffused light. This procedure was continued until the animal was seven and one-half months old when gradually, over a period of ten days, it was given more and more light (increased illumination of the room). In addition to observing the animal's behavior in relation to visual objects, the following experiment was performed. Training of an avoidance response was begun; twice a day, a shock plaque (a disk painted with vertical yellow and black stripes) was held in front of the animal and brought slowly toward him until an electrode made contact with his face and delivered a shock. When an avoidance response had been established, discrimination training was started. The shock plaque was shown, followed by shock if the animal did not make an avoidance response. Four other plaques were always followed by the food bottle. These "positive" disks differed from the negative stimulus in either one of the following characteristics: size, color, shape, and direction of stripes. Complete data are reported for only one such animal, Chow, and for two other animals—Faik, reared normally, and Lad, reared like Chow except that he received 90 minutes a day of patterned light stimulation.

Riesen reports that Chow and Kora (another chimpanzee reared in the same way as Chow) evinced difficulty in learning to recognize objects such as the food bottle. In the experiment, Chow showed delay in avoiding the shock plaque as compared to the normal control. Also his performance for the discrimination series as a whole was inferior to that of Faik or Lad. There are, however, discrepancies in the data which make interpretation difficult. For example, although Chow made many more errors than Faik before reaching the criterion for the shape discrimination, he was superior in learning the discrimination between the horizontal and vertical stripes. Certainly discrimination of the direction of stripes shows some degree of form perception. Chow had the greatest difficulty in discriminating size and shape and little difficulty with color as well as direction of stripes. The difficulty may be a cognitive one—i.e., perhaps it was difficult for Chow to abstract the size and shape characteristics from the more striking surface features of the plaque. The fact that Chow made more errors than Faik on the discrimination of *size* supports this interpretation; empiristic theory does not imply that the perception of size differences in objects of the same shape presented at the same distance must be learned. Another finding which is hard to understand is the fact that Lad, who had only 90 minutes a day of pattern vision for the first seven months of life, made fewer errors to all positive plaques than Faik, the normally reared animal. Yet Lad had many more failures than either Faik or Chow in reaction to the shock plaque. One animal, Mita, reared like Lad, but restricted in a supine position in a holder, apparently also had difficulty in learning to discriminate the bottle from other objects. This fact is not easy to explain.

It is also worth mentioning that for a long time after being placed in a normal environment, chimpanzees who had been reared without pattern vision had difficulty with pursuit of moving objects and with binocular fixation; they also manifested spontaneous nystagmus. Although Riesen's results cannot be fully accounted for by the presence of these impairments, it is plausible that such visual anomalies contributed to difficulty in clearly perceiving a unified and stable world of objects.

We do not wish to minimize the importance and interest of these studies. It is essential, however, to recognize the problems involved in the interpretation of the data. It is clear that no definite conclusions can be reached on the basis of studies employing so few subjects; the discrepancies mentioned above may simply represent individual differences. Nor do we know what are the effects of a restricted sensory environment on the cognitive maturation of the animal—there is evidence that animals reared under such conditions manifest some impairment of intelligence (70). Furthermore, the results of experiments in which subjects are raised in an abnormal or restricted environment lend themselves to two different interpretations. If a particular function or capacity does not appear or is retarded, this may mean either that learning is necessary or that the experimental conditions have disrupted the normal maturation of a function which may be innate. For example, Nissen, Chow, and Semmes (47) have shown that a chimpanzee who had been reared with little opportunity for tactual experience (his arms and legs were encased in cardboard tubes) was unable to solve a problem requiring tactual discrimination of two widely separated stimulus points. But, the "neonate chimpanzee responds differentially according to the location on his body of a tactual stimulus. Usually the principal movement is near the region of stimulation" (47, p. 494). Similarly, if a pain stimulus is applied to the cheek of a human infant, the infant's hand is brought to the cheek near the point stimulated (62). These facts suggest the possibility that some degree of tactual discrimination is innate and that the restricted experimental conditions have disturbed or prevented normal development so that the chimpanzee is unable to solve the discrimination problem. In spite of these reservations, however, we have no doubt that this type of experiment has brought us closer to a crucial test of the two theories of form perception discussed in this paper.

The effects of the deprivation of pattern vision on interocular transfer have been recently investigated in birds (64), cats (54, 55), and chimpanzees (9). It has been found that if, in rearing, both eyes have been exposed to patterned light (either simultaneously or alternately), the animal later trained monocularly on a visual discrimination problem transfers immediately to the untrained eye. If the animal is reared in darkness and then given diffuse light to one eye and patterned light to the other (or reared with both eyes stimulated by diffuse light), there is no immediate transfer of the discrimination to the untrained eye, regardless of which eye is used in the training; the discriminations are re-learned, however, with considerable savings. These results, while highly significant and quite surprising, are not relevant to the *perception* of form. There is no evidence that the animals could not see forms when the eye which had been given diffuse light was exposed for the transfer tests.[22] In fact, some of the data permit the inference that the lack of immediate transfer could not have been due to any difficulty in perceiving with this eye. First of all, even when an animal was trained with the eye which previously had been stimulated only by diffuse light, there was no transfer to the other eye, which had received patterned light (9). Secondly, an animal trained on three problems in succession failed in each case to transfer to the untrained eye (9). This animal re-learned the first problem with the untrained (dif-

[22] Riesen et al. (54) report that when the diffuse-light eye was first exposed, the cats bumped into objects and moved about quite slowly. But similar behavior occurred when the previously trained eye was re-exposed. Nissen et al. (9) do not report the initial behavior of the chimpanzees in their experiment.

fuse-light) eye so that perception must have been adequate when the second discrimination was begun. Furthermore, it would be difficult to argue that color differences are not perceived with the diffuse-light eye, yet color and brightness discrimination problems show the same effects as discriminations of form (**9**, **54**). These experiments, therefore, relate to the problem of recognition (i.e., accessibility to the trace) and reveal a limitation of the process of trace contact by similarity.[23] We would argue, applying the analysis given earlier (p. 280), that the stimulus seen with the untrained eye has the same appearance for the subject but it is not recognized as one which leads to reward. Why trace contact from one eye to the other does not occur so readily only in the case where both eyes have not had patterned light is, of course, a puzzling problem.

What Past Experience Contributes to Perception

Every theory must grant that some aspects of perception are spontaneous reactions to the stimulus situation; no one, for example, has argued that when the retina is stimulated by light of wavelength 700 mu., learning is required before the color red can be seen. But both logical analysis and empirical evidence support the conclusion that much more than color experience is immediately "given" as a result of innate organizing factors. Specifically, the organization of the visual field into shaped areas is not an outcome of learning—past experience cannot carve visual form out of initially formless perception. Other phenomena in perception considered to be innately determined were referred to earlier (p. 273).

But this does not imply that perception is *not affected* by past experience. On the contrary, it is only when some degree of innate organization is granted that the effects of learning can be more clearly understood.

1. The role of past experience in lending familiarity, ease of recognition, and discriminability, as well as meaning, has already been discussed. Perceptual experience is greatly enriched by the addition of these aspects; in the light of the distinctions made above, however, form perception as such is not affected.

2. In some cases, a memory trace can reorganize or modify a percept. An experiment by Wallach, O'Connell, & Neisser (**78**) demonstrates that a memory trace can impart three-dimensionality to a figure which at first was seen as two-dimensional. Wallach presented to a control group the shadow of a wire figure which was described by the subjects as flat. In the presentation to the experimental group, the wire figure was rotated, giving rise to a constantly distorting pattern on the shadow screen. The figure was now seen as three-dimensional (kinetic depth effect). Sometime later, when the same figure was presented in a stationary position (where it had been seen as two-dimensional by the control group), it was described by the experimental subjects as three-dimensional. Certain controls ensured that

[23] The fact that some perceptual phenomena diminish in strength or magnitude when transferred to the previously unstimulated eye reveals a similar limitation of interaction. If a rotating spiral is viewed with one eye, the negative aftereffect is greater with the same eye than with the other. Similarly, Gibson (**18**) found that the aftereffect of the inspection of a curved line is stronger with the eye used during the inspection period than with the eye which had not been stimulated. The influence of past experience on the perception of a wire cube is greater with the eye previously used (**1**).

the effect was a perceptual and not a cognitive one.[24]

To explain these results in terms of underlying functions we must assume the following: As a result of the moving presentation, a memory trace is left of a three-dimensional form. In the later stationary presentation, contact with this "three-dimensional" trace occurs on the basis of similarity of form and three-dimensionality is thereby imparted to the perceptual experience.

The experiment suggests the possibility that many of the purely figural cues to three-dimensionality (perspective, overlay, specific patterns such as a trapezoid giving rise to the percept of a rectangle at a slant, etc.) may be learned. Although empiricists have assumed such cues to be learned, they have never offered a plausible explanation as to how the learning takes place. In terms of the above hypothesis, the following explanation becomes possible.

Unlearned depth perception occurs on the basis of certain cues such as retinal disparity or the kinetic depth effect, and leaves *visual* traces. These visual traces can impart three-dimensionality to new figures, which otherwise would be perceived as two-dimensional (e.g., the Necker cube, perspective drawings, etc.). This assumption obviates reference to touch or purposive behavior as the source of the learned depth experience. The evocation of past experience effects occurs only when relevant traces are selected by the presence of a stimulus with some similarity to the previous three-dimensional percepts. By accounting for the initial depth perceptions and for the arousal of the appropriate traces, this hypothesis overcomes the logical difficulties in empiristic theories.

One might explain Leeper's experiment (**38**) in a similar way. On initial presentation the Street figure may be experienced as a jumble of fragments. After a period of inspection, the figure may suddenly look different—it is now recognized as a meaningful object. How this initial recognition occurs is not clear but in functional terms we may assume that the memory trace of the meaningful object is aroused in some way by the Street figure, and that this trace changes the phenomenal appearance of the figure. It will be recalled that when the Street figures were re-exposed several weeks later, they were instantly seen in their meaningful form. How is this effect to be explained? Following Wallach's reasoning, we may assume that the first presentation leaves behind two traces—one corresponding to the perception of the figure as an unorganized collection of fragments, and associated with it a trace of the figure in its meaningful form. Meaningful re-recognition of the figure means that the second trace is aroused. In accordance with the logical argument stated earlier, arousal of the first trace must occur and only then can the associated trace be activated in order to restructure the percept.[25]

3. Past experience within the experimental situation or experimental

[24] Informal repetition of this experiment at the laboratory of the New School for Social Research has failed to confirm that the effect is as easily obtained as the original report suggests. But even if such a memory effect occurs only occasionally it remains of great importance. In the present discussion, the experiment is cited primarily to illustrate how past experience might modify organization.

[25] Perhaps a similar process (i.e., the modification of a percept by a trace which is aroused by some kind of partial similarity with the still incompletely organized stimulus) could explain the selective influence of previous experience in ambiguous situations. The factual basis for this type of effect, however, is still unclear (cf. **27**, **56**, **57**, **58**, **59**, **66**).

instructions may produce a set which in turn influences the perceptual outcome. As noted above, there is as yet no explanation for the action of a set or attitude in modifying perception.

4. Prior experience may change the neural medium so that subsequent percepts are modified. This is not an effect of past experience in the usual sense because it is not specific to the contents of subsequent perceptions; it affects more or less indiscriminately stimuli which impinge at a later time in a specific region. Examples of this category might include: adaptations of various kinds, figural aftereffects and the negative aftereffect of movement. Evidence concerning the effects of long range adaptation to unusual stimulus conditions has recently appeared (**25**).

5. The studies of Ivo Kohler (**29**), however, suggest that adjustment to prism-produced distortions or to chromatic lenses cannot be understood merely in terms of local adaptations since the effects are dependent upon eye position. Thus, for example, *S*s wearing glasses, each lens of which consisted of a blue left half and yellow right half, in time adapted so that when the eyes were turned to the left the scene appeared less blue, and when turned to the right, less yellow, than at first. Furthermore, when the glasses were removed, *S*s reported aftereffects which are also dependent on eye position. With eyes to the left, the scene looked yellowish; with eyes to the right, it looked bluish. Similar adaptations and "situational aftereffects" occur with respect to distortions caused by the wearing of prisms. It is difficult to assess the full significance of these recently published findings, but clearly an important effect of past experience on perception seems to have been demonstrated.

6. Past experience may have an *indirect* effect by determining conditions which make other processes possible, although these processes themselves are not the results of experiential factors. The apparent oscillation of an objectively rotating trapezoidal window (**3**) may be understood in this way. If the window is seen as rectangular, other perceptual effects must follow. The perceived rectangularity itself may be due to previous experience[26] (an assumption which could be challenged by those who accept the principle of Prägnanz). Seen as a rectangle, the window cannot come into the frontal-parallel plane and must, therefore, be perceived to oscillate through an angle of less than 180°.

Another possible example of an indirect effect is furnished by the situation where those cues to distance which may be learned give rise to size constancy, which may be innately determined.

Conclusion

One can hardly take a dogmatic position in an area where, as yet, there exists so little decisive experimentation. Nevertheless, it is important to determine the status of a scientific theory in relation to present knowledge. On the basis of logical analysis and an examination of relevant evidence, we have argued for the thesis that various aspects of the phenomenal world and, in particular, the segregation and shape of visual forms are given by innate organizing processes. Percepts may be modified and enriched by experiential factors but the effects of such factors presup-

[26] Explanation of the apparent rectangularity in terms of visual traces makes more concrete the hypothesis which the transactionalists imply by such terms as "assumptions," "prognostic directives for future action," etc.

pose the prior existence of visual forms.

If the thesis defended in this paper is correct, perceptual organization must occur *before* experience (or personality factors which depend on experience, such as need, purpose, and value) can exert any influence. According to holistic concepts, currently so popular, psychological functions cannot be separated. But it is the relative independence of the perceptual organizing processes which makes possible an adequate phenomenal representation of the external world. Despite changing motives and emotions, phenomenal color, form, and space remain remarkably stable and generally correspond to the objective situation. Such correspondence is, of course, necessary for successful adaptation to the environment and the innate neural processes which yield this correspondence must themselves represent the product of adaptive evolution.

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