

What Do the Eyes Contribute?

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EDUCATION, AS FAR AS IT TAKES PLACE WITHIN the four walls of the schoolroom, must, by its very nature, stay at a distance from most of the events, objects, and purposes to which it refers. The world which education introduces to the child is represented by proxy. History lies in the past, foreign countries are beyond reach, social relations are replaced by the pushes and pulls within the team of pupils and teacher, and the usefulness of knowledge and skill cannot be demonstrated on the spot; it has to be accepted on trust. In the first grade of elementary school the teacher may take the class for a walk to show them the maple, the beech, and the elm. A few years later, the trees—if they are considered at all—have been reduced to words, statistics, line-drawings, photographs, chemical processes, and perhaps leaf samples. As education proceeds, it concentrates more and more on the two techniques of remote manipulation: words and numbers.

The advantages and the drawbacks of this procedure, profoundly different from the way a cat teaches her kittens and a master teaches his apprentices, need not be rehearsed here. I mention the indirectness of education in school only to remind us that the transmission and conservation of experience are more vitally important in this region of life than in any other. For the psychologist this situation raises a number of fundamental questions, one of which will be subjected in this paper to the particular bias of a particular observer, namely, the question: What do the sensory experiences of sight contribute to understanding?

Extroverted versus Introverted Theory

In dealing with this problem, the psychologist cannot avoid involvement in an age-old philosophical controversy, which in the last analysis rests on a fundamental difference of attitude. The extrovert contends that man functions under the impact of the outer world and that his ways of thinking about it and his image of it are dictated by the nature of that outer reality. The introvert considers the outer world amorphous; order, character, and lawfulness are imposed upon it by a mind stocked with ideas which are inborn, inbuilt, or adopted from other minds.

In view of this persistent polarity of approaches, even the traditional statement, "*Nihil est in intellectu quod non fuerit in sensu,*" is far from being a straight endorsement of the extrovert. Granted, it means on the one hand that all the subject matter of memory and thought derives from the perception of the outer world, and that even the elaboration of the imported material by means of selection, association, and generalization does not alter it in principle. But the *sensus* of the old saying may also be thought of as a storehouse of internally generated images—which would make the transfer from sense to intellect an entirely intramural affair.

The problem, then, concerns the relationship between outer world and inner world and, secondly, that between image and abstract concept. We ask: How much of the organization which we experience in the world as we know it is determined in the case of vision by the nature of the images impinging upon the eyes? How much of the operations of thought is performed within the medium of images?

Historical attributions may be dispensed with for our purposes. I shall simply say that we are heirs to a doctrine which maintains, first of all, that the stimulus material, as it arrives at the eyes, is in itself shapeless and, therefore, exerts no formative power upon perception. The human mind conglomerates certain portions of the visual field and keeps others separate on the basis of its gradually accumulated knowledge of what belongs together and what belongs apart. The doctrine also maintains that only particular instances can be perceived, *e.g.*, a particular horse or a house, so that general concepts either do not exist at all or can be arrived at only by a process of abstraction which leaves the percepts behind.

Let us note in passing that these two assertions do not match. If an individual percept can be obtained only by reference to past experience,

the reference would have to be to general concepts since there is no exact precedent for any new percept. In order to see a human face, I would have to rely on what previously perceived faces have told me about how facial features are made up. Such knowledge would be necessarily generic and, as a result, my new, present image would equally consist of generic facial features only. This, however, would contradict the second assertion, which maintains that percepts must be strictly particular. (Not to mention the most obvious flaw of any theory based on past experience: it hands the problem of perceptual organization to the past without explaining how percepts came about originally.)

“Physioplasic” versus “Ideoplasic” Art

The empiricist view reduces sensory perception to a mere underling and leaves all elaboration of the raw material of experience to the so-called higher processes of the mind. The grave consequence in education has been the traditional monopoly held by abstract operations. At the same time, the underlying psychological theory has run into difficulties. Among the facts that argue against it are the observations on early stages of primitive art. I have pointed out more explicitly elsewhere (2 and 3) that if early experiences were limited to strictly individual things, the drawings and paintings of children and primitives should reflect such individuality. Instead, they tend towards elementary geometrical and symmetrical shapes. In order to reconcile this evidence with the traditional dogma, Max Verworn, in a lecture on the psychology of primitive art (20), suggested in 1907 that there are two fundamentally different approaches to pictorial representation: “physioplasic” art is based on the faithful recording of individual percepts; “ideoplasic” art translates intellectual knowledge into visual schemata. “Even children growing up on the farm and therefore given to the observation of nature and protected from the overdose of conceptual material that education would impose upon them are nevertheless subjected from earliest infancy to an enormous amount of such material, which was never derived from their sensory experiences.” Van Scheltema, in his book on primordial art (19), agreed that the drawings of children are ideoplasic; but he maintained, against Verworn, that this is so because by the time children begin to draw they have already passed through the earlier physioplasic stage, at which they are limited to direct, particular experience. In addition to this intellectualistic hypothesis, other attempts have been made to reconcile the facts of

early pictorial representation with an outdated psychology of perception. Thus Victor Lowenfeld, writing on art education (13 and 14), had recourse to Alois Riegl's distinction of haptic and optic styles of art. He maintained that some children, because of their stage of development or individual disposition, will rely on their touch experiences while others paint what they see.

The most impressive recent example of this willingness to split the unitary process of artistic representation by an artificial dichotomy can be found in E. H. Gombrich's *Art and Illusion* (7). The book is a monumental attempt to devalue the contribution of perceptual observation. Gombrich suggests that the world of the senses is an impenetrable puzzle and that images are understandable only when maker and beholder share a set of conventions, by which statements about visual reality can be coded and decoded. At the beginning of his eleventh chapter, he describes the history of art as "the forging of master keys for opening the mysterious locks of our senses to which only nature herself originally held the key." Since, according to him, what we see as reality depends on what we expect to see, the effect of illusion is obtained when an image matches the preconceptions of the observer. Gombrich is well aware of the arguments that make the distinction between perceptual and conceptual art untenable; yet he insists that the ancient Egyptian or the child uses his concepts to represent what he knows, whereas the "Greek revolution" initiated a way of using such concepts for the purpose of presenting what is seen. A similar distinction in principle is made between Renaissance art and medieval art and between Impressionism and Cubism (4).

Transactional Theory

I have gone to some length to describe the formidable popular front of introverted theory, which would have us believe that the very image we receive from the outer world as well as any general concepts related to it must be credited to non-perceptual capacities of the mind. I shall have to refer in a moment to another powerful constituent of that front, namely, the so-called linguistic determinists. In the field of psychology proper, the traditional emphasis on past experience as the principal formative agent in perception has been given new luster by the recent demonstrations and formulations of the transactional school. The very concept of transaction should exclude onesidedness, and in fact the founder of the school, Adelbert Ames, Jr., has described perception as

the “ongoing interaction of three components of your total situation.” He was careful to point out: “. . . the demonstrations also disclosed that the content of perception was at least in part a consequence of the ‘object’ of the perception; that is, was dynamically related to unperceived light ray bundles impinging on your eyes and to your physiological structure patterns. The three: content, object, physiology make a dynamic triad—a triangle (1).” Nevertheless, the introverted slant has dominated the formulations of the school. Thus, in a booklet on perception according to the transactional approach, Ittelson and Cantor start out by establishing the central problem of perception as the study of “the degree of correspondence between the significances which we externalize and those which we encounter”; but the encounters drop out of sight when perception is defined later as “the process by which a particular person, from his particular behavioral center, attributes significances to his immediate environmental situation (11).”

Gestalt Theory

The main antidote to the prevalent introverted slant has come from Gestalt psychology. As soon as perceptual experiments were directed towards the behavior of the stimulus pattern as a whole rather than towards isolated elements, it became clear that a visual stimulus has a character of its own which strongly influences what is seen. To be sure, on its arrival at the retinae of the eyes, the stimulus is amorphous in the sense that there is no interaction among its elements likely to influence perception substantially. But it contains objective properties of shape and color—such as similarity, geometric form, symmetry, and complementarity—which steer the organizational process in the brain field. To cite just two experimental studies, one older, one recent: Gottschaldt showed that the parts which appear as discernible entities within a total pattern are determined by the relationship between the structure of the part and the structure of the whole (8). In the experiments of Michotte, the experience of causality—that is, the observed effect of the forces inherent in one object upon the movements of another—turned out to be an integral part of the percept itself, strictly dependent on stimulus conditions such as the relative direction and speed of the moving objects (15). This dependence of the percept upon the stimulus, however, is not a point-to-point relationship between items of the retinal and the perceptual fields, as Gibson—otherwise a strong

proponent of this approach—has asserted (5), but follows the rules of structural organization.

The compelling effect of visual structure operates not only in spatial patterns but also in time sequences; *e.g.*, in the perception of movement or in the interaction between memory images and direct perception. Thus the spatial and the temporal contexts act with and against each other. The outcome is determined by the relative strengths of the two; but the immediate presence of a strongly organized percept is very hard to overrule or even to modify by memory factors. Significantly enough, in practically all experiments demonstrating the effect of past experience, an ambiguity or some other structural looseness in the perceived pattern is seized upon by the memory trace or set.

As far as the relation of perception to the acquisition of general concepts goes, the Gestalt psychologist has to point out, first of all, that vision is not an isolated mechanism intent on recording stimuli for the recording's sake. The senses developed rather in the course of evolution as a means of coping with the physical world. Such coping, whether based on instinct or on learning, consists in dealing with individual things on the basis of what kind of thing they are. The individual case can be foreseen neither by instinct nor by learning. One copes with a staircase, a can-opener, a threat, or an offer by means of the properties they have as species. Hence perception, too, must be geared to generic properties from the outset. The level of generality will depend on how much differentiation the purpose demands. Early concepts will be very broad, to be broken down later.

Stimulus Equivalence Theory

The experimental evidence for what psychologists call "stimulus equivalence" refers mostly to reactions rather than perception, but to reactions based on perception nevertheless (12). The experiments strongly suggest that perception starts with broad generalities, but in certain cases the theory that goes with them clings to traditional assumptions. Thus when Pavlov found that his dogs reacted to a whole range of sound pitches after having been trained with a particular one, he inferred from the reaction that the originally specific stimulus had irradiated along an extended range of such stimuli, thus causing a corresponding generalization of the response (16). Related to this notion of generalization by oozing, as it were, is a tendency among theorists to explain stimulus equivalence by the alleged fuzziness of the percept

at early stages of development. According to this view, animals or young children are able to react to, say, triangular shape regardless of variation of size, proportion, or orientation for the same reason that may make a near-sighted man find all women equally beautiful. Gestalt psychologists have had to face this approach on early occasions, as, for example, in 1913, when G. E. Müller explained the gradual transformation of memory traces by the *Konvergenzprinzip*, according to which the mental images of different objects “converge with increasing imprecision toward an extremely imprecise image (22 and 23).” Gestalt psychology suggests, instead, that perception does not consist in the mechanical recording of stimulus material, either detailed or blurred, but in the grasping of structural features, which gives the character of generality to any percept and eliminates the difference in principle between seeing an individual thing and seeing a kind of thing, *i.e.*, between percept and concept (2).

This Copernican turnabout of the theory—according to which the early knowledge of the world does not develop from perceived particulars to abstract generalizations but is based on primary generalities within perception itself—explains many manifestations of the young or primitive mind. It enables us, for example, to recognize in the pictorial representations of children or archaic art the reflection of early stages of perceptual concept formation rather than to misinterpret them as the manifestation of an intellectualistic or haptic approach.

This new view, however, should not make us overlook the fact that after differentiated patterns have been acquired, generalization will often take place along the lines of traditional logic. In a paper on perceptual learning, the Gibsons forcefully make the point that learning is not a matter of “enriching previously meager sensations” with the help of past experience but of “differentiating previously vague (!) impressions (6).” They assert that learning does not consist in moving away from and beyond the percept but in the differentiation of the percept itself; *i.e.*, in the response to “variables of physical stimulation not previously responded to.” They report an experiment designed to show that subjects learn gradually to distinguish between very similar scribbles presented to them. While this demonstration is of great value, we must keep in mind that by presenting almost identical items and asking for discrimination, the Gibsons stacked the cards in favor of discrimination between items. If, on the contrary, subjects are faced with a set of very different figures and asked to find some similarity

among them—as, for example, in Hull's experiment of 1920 with Chinese characters containing a common radical (10)—the differentiation of the percept will lead to the discovery of similarities rather than differences; that is, to generalization. But here again, it is a thorough scrutiny of the percept that lays the ground for the progress of learning.

Linguistic Determinism

The power of organization inherent in perception has not been entirely ignored by the linguistic determinists. Benjamin Lee Whorf has commended Gestalt psychology for “the discovery that visual perception is basically the same for all normal persons past infancy and conforms to definite laws, a large number of which are fairly well known (21, p. 163)”; but he can hardly be said to have made these discoveries a genuine part of his own view of man's relationship to the outer world: “Segmentation of nature is an aspect of grammar. We cut up and organize the spread and flow of events as we do, largely because, through our mother tongue, we are parties to an agreement to do so, not because nature is segmented in exactly that way for all to see (21, p. 240).” Here again we are presented with the notion of the shapelessness of the perceptual world. Language, the supreme manifestation of man's capacity to detach himself from direct intercourse with reality; language, the entirely man-made medium which names things by arbitrary signs rather than by embodying them—language was predestined to be credited by the “introverted” theorists with the accomplishment of giving shape to the world. Edward Sapir, in his determined fashion, asserted that it was an illusion to believe that there could be thought without language. “Speech,” he says, “would seem to be the only road we know of that leads to it.” And there is an almost pathological tinge to the rhetorical question: “Would we be so ready to die for ‘liberty,’ to struggle for ‘ideals,’ if the words themselves were not ringing within us? (17, p. 17).”

It is possible that by now the introspective approach has passed its peak and is on the descent—if only because the detachment from the primary source of experience, the refusal to believe in the objective existence of what we see and what arouses us to action, and the exclusive concern with our own equipment are, by necessity, profoundly fatiguing. Refreshing breezes are not entirely missing. Harry Stack Sullivan, the one truly observant and imaginative psychopathologist after Freud, notes in passing: “Incidentally there are people who seem

completely staggered when one talks about nonverbal referential processes—that is, wordless thinking; these people simply seem to have no ability to grasp the idea that a great deal of covert living—living that is not objectively observable but only inferable—can go on without the use of words. The brute fact is, as I see it, that most of living goes on that way (18, p. 185).” And the mathematician, Jacques Hadamard, in a most illuminating chapter of his book on the psychology of invention in the mathematical field, reports: “. . . even after reading or hearing a question, every word disappears at the very moment I am beginning to think it over; words do not reappear in my consciousness before I have accomplished or given up the research. . . .” He asserts that he behaves in this way “not only about words but even about algebraic signs (9, chapter 6).” Hadamard, furthermore, in referring to Francis Galton’s introspective observations, comments: “Whether he is playing billiards and calculating the course of his ball or investigating higher and more abstract questions, his thought is never accompanied by words.” He also cites Alfred Binet’s investigation of chess players who play several games simultaneously without seeing the chess boards; the result “may be summed up by saying that for many of these players each game has, so to say, a kind of physiognomy, which allows him to think of it as a unique thing, however complicated it may be, just as we see the face of a man.”

Nobody denies that concepts—be they verbal or non-verbal—influence direct experience and help codify the results of perception and thinking. Our knowledge of these mechanisms has been considerably enriched, and we are by now protected from believing naively that the mind records reality with the mechanical faithfulness of the photographic emulsion. But our understanding of how the organism—animal, child, or man—copes with its environment would be severely hampered if we insisted on artificially splitting this unitary process into non-verbal and verbal behavior. And the emphatic testimonies of great scientists and artists to the effect that their creative thinking does not consist in the manipulation of words must give pause to every educator.

Requirements of Visual Aids

If, after surveying the state of the theory, we look at the educational situation, we realize, first of all, that the value of direct visual experience is admitted by everybody. Particularly, the contribution of photography in all its forms has revolutionized teaching and learning in most areas

of study. The main point to be made in the context of the present article is, however, that the use of visual aids may be hampered by the blinders of the introverted approach. This approach, we noted, does not deny that visual material is indispensable; but it thinks of it as raw material only. If the image of the world, outside of the schoolroom or indoors on the projection screen, is believed to be amorphous in itself, a film or lantern slide will be considered satisfactory if it is an authentic recording of the pertinent subject matter. Suppose, for example, the processes of cell division or the child-rearing practices on a Pacific island are to be studied: it will suffice that the pictures be genuine and complete since all the selecting, comparing, generalizing, and interpreting are assumed to be accomplished by the "higher" mental operations anyway.

If, however, the educator has come to understand that all these components of learning are inherent in the very act of perception and that truly productive thinking—during, after, and before direct perception—is done by means of images, he will realize that the visual material will have to fulfill certain requirements in order to do its job.

What are some of these requirements? First of all, we need to keep in mind that perceiving consists in the grasping of structural features. Consequently, all subject matter must be presented in a way that makes such grasping possible. At the most elementary level: How many separate objects are seen in the picture? Does this number correspond to the intended meaning? Or are objects being separated that should be perceived as one, or vice versa? We have no right here to rely on the student's expectation or knowledge. The picture itself must steer perception. How it accomplishes this feat has been demonstrated in great detail by Gestalt psychologists. The shape of contours, the contrast of brightness, the structure of the over-all pattern will determine what is seen. Whether an object fades into the background or stands out as a segregated entity depends again upon perceptual factors; and the meaning of what is seen is influenced by this visible relationship of figure and ground.

More subtly, we notice that objects are not simply separate or united but relate to each other in different degrees, thus creating a complex hierarchy which leads from the over-all pattern to the smallest detail. This varying closeness of connection between elements is not automatically transmitted by just any authentic photograph. Contrasts may be blurred or misleading breaks created if angle, distance, and lighting

are not judiciously chosen. Often a photograph, in spite of all its authenticity, is not the best visual interpreter; rarely will it do the job without the help of other means such as schematic drawings, graphs, *etc.* A good drawing identifies and interprets the subject by means of clearly defined visual properties. A photograph, which is a mechanical impingement of light stimuli, must be carefully controlled in order to explain the subject rather than merely expose the student to it. It is a pious superstition to believe that the student sees, say, a printing machine or a sperm fertilizing an egg, just because the pictures he looks at have been taken of these objects.

To see a printing machine means to understand certain things about it—things that appear within the picture as shapes, directions, and movements. In order to truly perceive what the sperm is doing the beholder must see “penetration” translated into a clear-cut sequence of moving or yielding elements of form. I have watched groups of schoolchildren stare at the small television screen on which vague smudges of black and grey purported to represent the dikes of Holland or the heartbeats of a frog. Whatever effect these phantoms may have had upon the children, it was not visual education.

Visual education is based on the knowledge that every picture is a statement. The picture does not present the object itself but a set of propositions about the object; or, if you prefer, it presents the object as a set of propositions. These propositions are stated in visual language. For instance, a comparison is made by means of visible similarity and parallelism. A sequence is shown by continuity. Cause and effect presuppose an observable proximity in time or space or both. Change is no change if it is only talked about, not seen.

Visual education presupposes that the world can present its inherent order to the eye and that seeing consists in understanding this order. The human mind must bring into play all of its capacities at the very first contact with the object; there is no preparatory phase of pure reception. The thinking on which all true learning is based takes place at the source and continues to draw on it.

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Variations of Projected Image

The correspondence of the visual field to the total retinal image is an anatomical point-for-point correspondence which is not hard to understand. The correspondence of the visual world to the total retinal image is an ordinal correspondence which is more difficult to analyze and specify. But the latter correspondence is no less literal and exact, we may believe, than the former, and it is clear that the way to determine it is to find the obscure variations of the projected image which yield coordinate variations in perception.

—James J. Gibson, *The Perception of the Visual World*. New York: Houghton Mifflin Company, 1950. p. 76.