INTERDISCIPLINARY THEORY AND AMBIGUOUS FORM PERCEPTION

Elaine L. Kleiner

Indiana State University

A satisfactory theory of interdisciplinary study must explain how the brain employs interpretive frameworks, "disciplines," or "particular styles of knowing" to organize information or "reveal something about its objects of study." Visual illusions, the kind of pictures and geometric forms which spontaneously shift their principle aspect when they are looked at steadily, may be useful in developing such an explanation. "Although several visual illusions were known to the ancient Greeks, they have been studied experimentally for only little more than a century."[1] Swiss naturalist L. A. Necker first described such illusions scientifically in a letter of 1832 to physicist David Brewster. In this letter Necker described a cube which reverses in depth either through changes of eye fixation or otherwise quite spontaneously. Such effects were found not to be perceptual distortions of retinal images, but rather "alternative interpretations of the image in terms of possible objects."[2]

When one looks at a "Necker Cube," first one of its faces seems to be at front and the other at back. Then, as one looks steadily at the drawing for a while, it suddenly reverses and what was the back face becomes the front one. This phenomenon does not occur with all drawings of cubes but rather only with those which are ambiguous or "multistable" forms. When we look steadily at a picture or geometric figure, the information received by the retina of the eye is relatively constant and what the brain perceives usually does not change. If, however, the figure we are viewing is an ambiguous or "multistable" form, what the brain perceives may change rapidly without any change in the message it is receiving from the eye.[3] The classic demonstration of this phenomenon was introduced by Danish psychologist Edgar Rubin in his 1915 monograph dealing with visually perceived form as a function of the relation of figure to ground. In this work Rubin presented the "reversible goblet," a white-on-black silhouette which can be seen either as a white goblet on a black field or two black profiles facing each other on a white field.

It is believed ambiguous figures of this kind provide the viewer with a sensory input for which there are within the brain two or more possible representational systems that are quite different and about equally good by whatever criteria the perceptual system employs. When alternative representations or descriptions of input are about equally good, the perceptual system will adopt sometimes one and sometimes another. Such perceptions are termed "multistable" and they have their counterparts in the physical world. For example, the multivibrator flip-flop circuit in vacuum tubes or transistors displays multistability in electronic circuitry.[4]

Reversible figure-ground designs appeared as early in the work of the late Dutch graphic artist Maurits C. Escher as 1921 when he was 23 years old. Escher's own commentary on his prints make it clear he was familiar with the experiments on figure-ground perception conducted by Edgar Rubin, together with Kurt Koffka's book *Principles of Gestalt Psychology* which summarized Rubin's results, and studies conducted by Molly R. Narrower, Koffka's student. In 1922, Escher carved a woodcut called "Eight Heads" based on principles of figure-ground reversal. In this work, each head exactly fills the space left between neighboring heads and acts alternately as figure and ground, depending on the viewer's attitude. Escher classified "Eight Heads" together with the later works "Sky and Water I" and "Day and Night" under the heading "The Function of Figures as Background," observing that "Our eyes are accustomed to fixing on a specific object. The moment this happens everything around becomes reduced to background."[5] This description was in keeping with Rubin's analysis of similar figures.

Rubin had observed that usually in ambiguous patterns, one sees the smaller enclosed form as figure by contrast with the larger surrounding expanse of ground. The figure has a "solid-object quality," whereas the ground takes on a "film quality." The figure protrudes and the ground recedes while the contour between the two is seen as belonging to the figure and not the ground.[6] Escher also noted that "the act of tracing (a contour line) is a complicated business. On either side of it, simultaneously, a recognizability takes shape. But the human eye and mind cannot be busy with two things at the same moment, and so there must be a quick and continual jumping from one side to the other. ..."[7] Contemporary investigators of computer simulation have also observed that it is quite "impossible to see both sides of a contour as figures at the same time. Trying to think of the halves as two pieces of a jigsaw puzzle that fit together does not help; the pieces are still seen alternatively and not simultaneously."[8]

Escher's experiments carried him deeply into studies of the nature of multistability in perception. By 1938, he had created two of his most striking wood-cuts, "Sky and Water I" and "Day and Night." In these works the ground slowly becomes figure and the figure becomes ground while forms in the center remain equivalent in extent, internal design, light-dark contrast, and simplicity of contour. Such equivalence makes the figures ambiguous, and a rapid reversal is

the result. In appreciating these works one realizes that when a picture can be seen as either of two familiar objects, for example, a duck or a rabbit, visual input is matched immediately in the mind with some kind of acquired or learned schemata of classes of objects. What these schemata consist of–whether they are like composite photographs or like lists of properties–remains a matter of scientific dispute. "In any case the process of identification must involve some kind of matching between the visual impact and a stored schema. If two schemata match the visual input about equally well, they compete for its perceptual interpretation; sometimes one of the objects is seen and sometimes the other. Therefore one reason ambiguity exists is that a single input can be matched to different schemata."[9]

Why one aspect of an ambiguous figure, once it is "locked in" or stabilized in the mind, should ever give way to the other remains a matter of controversy. A person can look for quite a long time at an ambiguous figure and see only one aspect of it. Because on occasion it is not until the other aspect is pointed out that the figure spontaneously alternates, it has been concluded that the initial contact and the associated organization must entail a type of learning.

Under natural conditions ambiguity is rare and many factors co-operate to resolve competition between rival-object schemata. An enclosed area or smaller area is favored as figure. Elements that are alike are grouped together. Regularities are grouped together. Readily seen figures are usually simple, compact, and symmetrical. A familiar figure is easier to perceive than one which is less familiar.

> The perceptual system has an impressive ability to segregate and sort objects from one another. Along with distinguishing figure from ground, the system must group the fragments of information it received into separate sets that correspond to real objects... When alternative groupings are about equally good, ambiguity results.[10]

Some principle of minimum complexity seems to govern the perceptual system in that it is "motivated" to "represent the outside world as economically as possible, within the constraints of the input received and the limitations of "encoding capabilities."[11] Input corresponds to a schema that is already "well established by experience and can therefore be encoded or described ... most simply in terms of that schema."[12] A schema therefore may be a "world view" though all schema need not be world views. A schema differs from a "perceptual screen" in that it constrains interpretation rather than perceptual input itself. The system is designed to find its way to stable states that are simplest by several criteria. According to investigators, a reversing figure alternates more rapidly the longer that it is looked at. Possibly when one schema becomes "fatigued" or "satiated" or "adapted," it is overcome by its more fresh and exciting alternative. Electronic circuits manifest this characteristic. "However, if the representational system reflects the laws of the world it represents, the same object cannot

traverse two different paths simultaneously or occupy two different places at once."[13]

Perception, then, seems to involve associating learned or herditary given information with input. As one researcher describes it:

> Perception seems to be a matter of looking up information that has been stored about objects and how they behave in various situations. The (input) does little more than select the relevant stored data. This selection is rather like looking up entries in an encyclopedia: behavior is determined by the contents of the entry rather than by the stimulus that provoked the search. We can think of perception as being essentially the selection of the most appropriate stored hypothesis according to current sensory data.[14]

Such a "look up" system would be of superb survival value to a living creature, instead of having to rely on a control system that must wait to respond until enough input has been acquired, a creature with stored up information can continue to act in the temporary absence of relevant information or even when information is inadequate. Unfortunately, however, this very strength can become a danger for it means such a creature could continue to function even in ignorance.

These characteristics of perceptual systems have exciting implications for those seeking to understand relationships between "disciplinary" and "interdisciplinary" thinking. It is possible to think of many kinds of learning in a sense as intricate acts of perception. From this point of view, a problem for study might be thought of as a kind of informational "input" which the mind makes sense of by using any one of a number of learned available representational systems or "disciplines." In simple cases, input matches system and one studies the problem in a "disciplinary" way. In more complex cases, input or problem may match equally well with more than one good system of representation or "discipline." These are the situations we have tended to call "interdisciplinary" in that there seems to be more than one good way to represent the same material. If Escher and others are correct, however, it would appear more accurate to call such situations "multi-disciplinary" for there could be no informational input processed simultaneously by two disciplines or representational systems any more than it is possible to perceive both an ambiguous figure image and a ground image simultaneously. Rather, given a complex problem it is reasonable to assume the mind would apply first one schemata or discipline (with borderline input enclosed within that schemata) and then would alternate to apply another discipline or representational system, in the words of one interdisciplinary theorist:

> Most interdisciplinary work begins with a problem that has been addressed by more than one discipline. Once aware of the multiple treatments, the "complete scholar" feels the challenge inherent in the situation. …(He) then sets out to demonstrate that (his own expertise is the last word) and to refute the products of other disciplines. …Or, (he) finds that his own discipline has falsified the

> question; (and he) redefines the subject as one that transcends the boundaries of (his) particular discipline.[15]

In terms of redefinition of a subject, it is important to remember what Escher discovered about the tendency of mind to "lock in" on one way of perceiving a field and to stay with that approach until encouraged to perceive differently. This failure of mind may explain why intelligent men and women may look at the same field--say, urban studies--and perceive only the contribution of their own field to that study to the exclusion of others whereas other perceivers may identify many contributors. In many cases, only one schemata or "discipline" will match a field input, as for example, "photosynthesis" matches "biological studies" much better than "literary studies." However, in other cases, as, for example, the field of "environmental studies," two or more schemata or "disciplines" can be used equally well to separate essential features of study from background. Thinking of the environment as a scientific field pulls certain elements forward and makes others back-ground; thinking of the environment as a political field alters these arrangements as would thinking of the environment as an aesthetic field.

If continued study of a problem reveals it is in essence a "multistable form" in that two or more disciplines can be employed about equally well to reveal something about it, one of a number of consequences become possible theoretically. First, the mind might alternate more and more rapidly between disciplines on an "excitement-exhaustion" cycle and this "multidiscipiinary" condition might be as close as one could come to true "interdisciplinarity." Second, unstable conditions may encourage the formation of a new "discipline" which better represents the problem at hand than existing disciplines might. Such a situation might best be called "crossdisciplinary" or "transdiscipiinary." And, finally, it is possible that the mind might be able to hold a "neither-and-yet-both" hypothesis however briefly on the problem. To hold two or more schemata in mind simultaneously may be physically impossible. Yet, this condition should perhaps be called truly "interdisciplinary" (in that it exists between disciplines) and also "highest truth" in that only in this situation is the mind liberated from its interpretive screens enough to penetrate to the interconnectedness of all phenomena, to Heraclitus's world of flux, interpenetration, and transformation, to the "orderly disorder" that Escher tried to represent with his art.

Studies of perception would suggest that the way to lead students to consider multidisciplinary, transdisciplinary and interdisciplinary problem solving would be to begin with a multistable or ambiguous problem, apply a discipline until its explanatory powers are exhausted, and then seek engagement of other disciplinary perspectives. In other words, one transcends disciplinary thinking only when one senses that an available schema will not satisfactorily explain a problem. It is important to remember here that the mind appears to have been created in such a way that it acts as if it knows what it is doing even if it does not possess very much information. This characteristic suggests multi- disciplinary

perspectives become visible only to those who learn a discipline thoroughly enough to sense its limits and not to those who are less well informed.

It has been suggested that all significant problems--problems with existential force--are multistable forms which transcend disciplinary lines.[16] If this is the case, we need courses and a curricula in our schools which confront students with ambiguous problems demanding rapid shifts between several mental disciplines for their full comprehension. For such minds may be better prepared to confront problems engendered by complex twentieth century living.

NOTES

[1]Richard L. Gregory, "Visual Illusions" in *Readings from "Scientific American": Mind and Behavior* (San Francisco: W. H. Freeman & Company, 1980), p. 95.

[2]*Ibid*.

[3]Fred Attneave, "Multistabiiity in Perception" in *Readings from "Scientific American": Mind and Behavior* (San Francisco: W. H. Freeman & Company, 1980), p. 107.

[4]Attneave, p. 116.

[5]Marianne L. Teuber, "Sources of Ambiguity in the Prints of Maurits C. Escher" in *Readings from "Scientific American": Mind and Behavior* (San Francisco: W. H. Freeman & Company, 1980), p. 135.

[6]Teuber, p. 136.

[7]*Ibid*.

[8]Attneave, p. 107.

[9]Attneave, p. 111-2.

[10]Attneave, p. 109.

[11]Attneave, p. 115.

[12]Attneave, p. 114.

[13]Attneave, p. 111.

[14]Gregory, p. 104.

[15]Guy V. Beckwith, unpublished letter, Auburn University, 1984.