CHAPTER 5

The Perception of Pictures and Pictorial Art

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I. INTRODUCTION

In this chapter, I discuss what perceptual theory must learn from, and may contribute to, an understanding of pictorial art.

The importance of perceptual psychology to the applied arts is reasonably clear. The communications industries—film and video, the news media, advertising and packaging, entertainment—must know how to specify and produce given colors, what resolution is needed for presenting pictures and text, what fonts and formats are most legible, and above all how to depict events and scenes (virtual space and movements) that do not in fact exist. A great many similar questions in vision and audition, as well as more cognitive questions about attention and comprehension, need answers each day; these answers come more from intuition, and from trial and error, than from reliable information, although the knowledge base is expanding.

Two areas of communications research are not so straightforward: the interaction of the expressive features of the medium and its substantive content, and the nature of the display or presentation as an intentional interpersonal act. Even the most seemingly transparent and potentially automatic process, like the making of a photograph, entails a selection and a preparation—a directed effort—that implies a presenter with some purpose and that can make each member of the audience a participant in an implicit dyadic communicative act (e.g., Why is he showing that in such unexpected detail?). This is probably an extremely important aspect of

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every artistic presentation, but it is still true that (as I wrote in 1978) we have barely begun to assemble an analytic logic for communicative acts (Grice, 1968; Schmidt, 1975; Searle, 1969; see Clarke, in press).

These points become central in any attempt to distinguish fine from applied art, presumably a distinction based on *aesthetics* (for now, consider aesthetics as disinterested evaluation). Applying a concept of disinterested evaluation to paintings, which can be enormously costly investments, seems somewhat oxymoronic. Where options are available, where a tradition provides the background against which one displays one's own mark and originality, and, above all, where there is a great deal of Veblenesque prestige and gross financial investment at stake in assessing a given artistic presentation as good or bad (and thereby establishing an artist as worthy of investment), simple issues and unequivocal criteria do not exist. In the applied arts, there are usually more or less measurable criteria that can theoretically be drawn on. There, consumer preference measurements (often using techniques borrowed from traditional experimental aesthetics; see Woodworth, 1938) can at least in principle be subject to validation procedures. But with objects or presentations produced "for their own sakes," a great deal of the appreciation of the work depends on the education that enables the viewer to (1) place it in its tradition, or in its line of development; to (2) exercise the expertise that this requires and—perhaps most important in ensuring the stability of the investment—to (3) contemplate the object as an evocative piece of history.

Artistic provenance and tradition are *potentially* susceptible to rigorous pursuit by art historians, and at least some of the many societal functions that art serves are similarly assessible. Various functions (from sensory pleasure through philosophical reference to providing the motor for social change) have been announced, at one time or another, to be *the* basis for evaluating artistic merit. Both philosophers and experts on art disagree within their ranks, and some deny the possibility of an acceptable definition of either art or aesthetics (Kennick, 1958; Weitz, 1960). Some artists maintain that the only opinions worth considering are those of other comparable artists—special pleading that may, nevertheless, be valid where it reflects the artist's actual goal of achieving original and notable solutions to problems posed by the history and demands of the art form.

My own bias is that there is no single realm of art, even within the making of pictures. Many different activities are lumped together that have different purposes and diverse criteria; what is presently called *art* is more a matter of historical and sociological accident (and vested interest) than anything else. This is compounded by the fact that people really cannot, by introspection alone, provide effective analyses of why they seek exposure to what we will call artistic presentations (paintings, dance, motion pictures, music, architecture, etc.) any more than they can coherently and validly explain their choices in more trivial areas, such as fashion design, popular music, automobile styling, and so on, all of which are aesthetically driven applied art.

I will not maintain a distinction between pure and applied art here, except where it is natural to the discussion.[1]

It seems natural to divide the functions and criteria of the perceptual study of artistic presentations in the following three ways.

A. Pictorial Art as Representation and as Communication about the World

Many perceptual treatments of visual art deal solely with its representational function. Such analysis ignores those art forms, such as music, dance, and abstract paintings, that may have no representational or programmatic content, although they may have descended from representational activities. Other art forms, such as architecture, only rarely attempt to represent something. Yet pictorial art, certain acting, models, diagrams, and architectural design *do* aspire to some degree of objective communication. We would surely use pictures for their representational functions regardless of their artistic and other values, as we would continue to use clothes and buildings even if we had no care for their appearances. It is often cause for wonder, among the educated as well as among the unlettered, that some artists could render the likenesses of portrait sitters and their household goods so faithfully.

Making a surrogate that faithfully mimics to the eye the effects of the represented scene or event has lost its aesthetic interest per se (although convincing "special effects" and computer-generated images of dinosaurs and interstellar battles may still invite a little attention and wonder). But ways of making a portrait that is even more like the sitter than is the sitter, remain a matter of interest. Innovation in the manner or style of representation will surely continue, which introduces the two nonrepresentational functions, expression and aesthetic value.

B. Art as Expression: The Communication of the Artist's State, Feelings, or Identity

The ability of art to move the audience emotionally or to express how the artist feels is often taken as the sole touchstone of artistic merit. It is clear, however, that presentations can be expressive, yet not be regarded as good art (even the crudest forms of advertising, propaganda, and entertainment can move the audience), and that much art lacks both representational *and* emotional content aside from what is sometimes termed the aesthetic emotion, which provides the third function.

[1] The teenager immersed in assessing current musical performers is acquiring culture and an appreciation of that art by means that probably draw on the same mechanisms that contribute to a more classical cultural education, although the latter might provide more continuity to society.

C. The Aesthetic Function: Art as Pleasurable, Interesting, or Engaging

Defining the beautiful and pleasurable in terms of physically measurable canons or prescriptions has been attempted since antiquity. The reward value of the pleasurable has long been measured by asking subjects to make preference judgments and, more recently, by recording the subject's tendency to keep looking or listening (the opposite of boredom or habituation), which is more interesting to those theorists concerned with understanding perception as a motivated, constructive process.

These three headings are, of course, not completely separable nor exhaustive. Most writers agree that what makes an artistic presentation more or less successful, more or less sophisticated and deep, is the extent to which these diverse functions (and yet others) can be met in mutually reinforcing ways, using the expressive features of the medium in concert with the content (a desire often expressed in connection with poetry). However, any museum attests, I believe, to the fact that all functions need not be embodied in any one work of art.

We take up a selective survey of perceptual problems and research in each of these three areas.

II. REPRESENTATION AND COMMUNICATION ABOUT THE WORLD

A. Representational Pictures and Perceptual Theories

Perception textbooks that consider art at all treat representational pictures as surrogate objects that act as likenesses because they present the eye with much the same *pattern* of light as would the scene itself. This treatment must engage, unequally, all the perceptual theories.

A glance at the older traditional perceptual theories will distinguish the different kinds of data and analyses that they can bring to art. Associationism—empiricism, the oldest theory, originally assumed that all conscious experience consists of present sensations, of memory images of previous sensations, and the arbitrary linkages between them forged by the individual's mind in its encounters with the structure of the world. *Gestalt* theory rejected these atomistic premises, explaining that what we perceive reflects the characteristics of underlying brain fields. *Ecological realism,* which today remains in this regard much as Gibson developed it, reanalyzes the light reaching the eye to reveal rich information that might (it claims) account completely for veridical perceptions of the world without invoking the mediating processes and memories of associationism, or the organizational processes of Gestalt theory. This approach is uniquely challenged by the fact that things can be recognized from their pictures, as will be shown. Finally, there is the new-old attempt, which is usually referred to Hebb and Piaget, but in fact reaches back to Helmholtz (1909/1924), to view perception as an active process of fitting "mental structures" or "mental representation" (hypothesized objects, scenes, and events) to selected sensory samples, thus building selective attention and schematization, or abstraction, directly into the heart of the perceptual process. The Hebbian approach is clearly dominant today (though sometimes unacknowledged) in the theory and research of cognitive neurophysiology and computer vision.

Within the classical empiricist approach we can distinguish two components—a sensory psychophysical analysis (dealing with local "points" of light), and a cognitive empiricism, as in Helmholtz's doctrine of unconscious inference, which is that *one perceives those objects and events that are most likely, on the basis of past experiences, to fit the present pattern of effective sensory stimulation.* This gives two purely psychophysical approaches to perception (classical and Gibsonian) and two that invoke mental structure (Gestalt theory and those deriving from Helmholtz and Hebb). All approaches have been used to discuss all three functions (representation, expression, and aesthetic value). I consider representation first, and at greatest length.

B. The Psychophysics of Surrogates

To Leonardo da Vinci, the painter must be able to present a likeness of the world, using skills that could be learned in part by tracing the objects to be represented on a pane of glass that is interposed between artist and scene. By studying how the tracings on that picture plane are transformed by different dispositions of the objects in space, the artist learns what we now call the pictorial, or static monocular *depth cues.*

Aided by the geometry of perspective, as introduced or reintroduced by Brunelleschi in 1420, and explicated by Alberti in 1435 (see White, 1967) and by da Vinci's principles for modeling surfaces through shading and shadows (see Braxandall, 1995; Hills, 1987), it was now possible under the proper conditions to present the stationary monocular observer with approximately the same spatial distribution of light as would be given by the represented scene. In addition to trying to imagine how to represent the chosen scene, artists could also consult masters' notebooks and apply the rules (e.g., perspective). Assisted by devices like the camera obscura and the camera lucida (Kemp, 1990; Wheelock, 1979), the achievement of the same input as would perceptual reality (Danto, 1986, p. 12) became a practical goal. With the development of photography, this goal could be achieved "automatically," and in any case offered a great number of substitutes for masters' sketchbooks.

But a picture may be optically correct and yet fail as an effective surrogate. Da Vinci knew the limitations of this method: The viewer must stand in one location and use only one eye, and the picture must be without surface texture of its own, etc., or the flatness of the picture will be betrayed; therefore, *in general, the viewer cannot be fooled* by such simulations. To varying degrees, and for special purposes, these limitations can be overcome. For example, the cues to flatness and texture of the surface may largely be overcome by restricting the position of the viewer and by painting the scene on some surface that is not in the projective picture plane (e.g., using the ceiling of the nave of a church as the surface on which to paint the continuation of the wall produced the convincing illusion of an additional story [Pirenne, 1970], or by drastically restricting the depth being portrayed in a trompe l'oeil painting, etc.).

Once it has been decided *what* is to be portrayed, and where the viewer stands relative to the canvas and to the scene being represented, decisions as to what the *arrangement* of lines and patches of color on the canvas should be becomes merely a task for following the geometry and mixing the pigments—or, with the advent of chemical and electronic photography, using the right lenses and adjustments in the camera and its display. So far in our account, psychology has contributed only the raw materials given by the psychophysics of acuity and color mixing. Geometry contributes the patterns in which the colors are to be distributed, and we have a technology for making representational pictures. After Daguerre replaced the artist's canvas with light-sensitive plates in 1839 (Szarkowski, 1973), the surrogate, *as I have been considering it so far,* does not need the artist. But that is because so far I, like the SMPTE (Society of Motion Picture and Television Engineers) engineer or the vision scientists, have been considering the matter in a very narrow way.

And in any case, this automatic process describes a way to make pictures, not how it is that they are perceived as being like what they represent. As da Vinci said at the outset (White, 1967), the fact that the picture's surface is almost always quite recognizably flat, and usually viewed binocularly from changing positions, makes it desirable to violate projective geometry (see p. 164). And even the matching of the colors in the scene by trying to match wavelengths and their intensities in the light offered by the picture would be quite useless, as pigment limitations, human spectral sensitivity functions, and the phenomena of simultaneous color contrast make virtually certain. Very little is left of the idea of pictures as surrogates, or of *physical* fidelity as a measure of their accuracy of representation.

It is true, of course, that once the pattern on the canvas is established using the geometrical optics of the Renaissance, we can match the appearance of each separate point on the picture's surface to its corresponding point within the real scene, if we can correctly mix the pigments (or set the phosphors). Rules for classifying the possible colors had to be learned by the apprentice; fully developed, they can now be found, with the minimum palettes for additive and subtractive mixtures, in most introductory perception texts. They will not by themselves suffice: the range of pigments' reflectance is much smaller in any scene that includes specular reflections, light sources, and so on; moreover, contrasts effects characteristic of the scene (e.g., the induced hue of shadows in the open air) are not achieved simply by matching *hues* on canvas to those in the scene, point by point. The phenomenon of simultaneous contrast may be used to mitigate this limitation: by juxtaposing shadows, a region's apparent lightness can be enhanced, as notably exploited in the chiaroscuro (patterning of light and shade) of Rembrandt and de La Tour (Hochberg, 1979). A growing attention to induced colors, like those in shadows, that carries forward through Corot to the Impressionists, made the informed use of contrast an important skill.

Given a working knowledge of the laws of color mixing and color contrast, and with relatively few pigments or phosphors, the painter, printer, or display engineer can approximate the apparent colors of a wide variety of objects under a wide range of lighting conditions. In addition, the patterns of color and the afterimages that they produce can generate effects of *vibrancy* and movement, as taken to their extreme in *optical art*.[2] Less obtrusively, these effects, to which all high-contrast contours are prone, were deliberately used by many of the Impressionists, for what I take to be the following purposes.

Pigments can be mixed in various ways (such as physical intermixing, superposition by glazing, etc.) that provide subtractive mixtures by successively interposed filters of pigment; alternatively, colors can be mixed additively by placing small patches next to each other. If these patches fall below the limits of acuity, an additive optical mixture results. This, in effect, is what the pointillist painters came near doing, in their attempts to present the light from the scene scientifically, preserving a range of reflectances and saturations that would otherwise be lost in the process of subtractive mixture. The patches used in most Impressionist paintings, however, are much too large to be below the resolving power of foveal vision at practical distances (e.g., perhaps 70 ft for a Monet, 300 ft for a Van Gogh). How then does color mixture occur? Partly, because assimilation rather than contrast occurs when different patches fall within the larger receptive field associated with the individual retinal cells serving to detect the individual patches (Jameson & Hurvich, 1975). Interacting with this is the factor of the much lower resolving power of parafoveal and peripheral vision as compared to foveal vision. From the right viewing distances, the mixture occurs in some but not all of peripheral vision, producing a vibrancy otherwise offered at contours in daylight illumination (Jameson & Hurvich, 1975), and raising an issue that further complicates any attempt to think of the picture as a surrogate for the scene.

When the viewer's gaze is fixed on some region that is painted in full detail, the lack of detail elsewhere may not be evident. Conversely, the artist may lead the viewer to look predominantly at one place by only giving detail there. Rembrandt and Eakins (among others) have left clear examples of such usage, and when I stand at the correct viewing distance from these paintings and look at the detailed focal region, the pictures look complete, even though they may be blurred blobs elsewhere.

In Impressionist paintings, however, the fovea finds incoherent patches *wherever* it is directed. The viewer quickly discovers that it is precisely that apparently meaningless pattern that when seen by peripheral vision appears as the meaningful, depicted landscape and people. (This contributes, in my opinion, to the felt *rightness* and inalterability of the artist's work, which I take to be a great deal of what is

[2] This was a brief flurry of abstract designs, in the 1950s and 1960s, in which the moiré effects of regular high-contrast patterns, superimposed on their displaced afterimages by the slight tremors and unnoticeable movements of the eye, amplify the tremors and make them grossly visible (Oster, 1977).

FIGURE 1 One of these figures, modeled after a sketch by Seurat, has had a substantial region of the small dots inverted (from Hochberg, 1994).

meant by aesthetic quality in real paintings.) It is like the first unstudied impression of the world itself, only a tiny part of which is seen in detail by the first few glances. The meaningless patches themselves are generally too unrelated to be stored from glance to glance: a set of patches in one of the figures in Figure 1 has been inverted, but even with knowledge it is very hard to tell which. And because a painting's flatness is most evident to foveal vision, and in such paintings no depth cues are given in foveal vision, the immediate conflict between local depth cues and pictorial surface is greatly lessened.

We are now far from a surrogate that can be defined physically, but we can see how, by taking the eye's characteristic response to color and detail into account, the departures from fidelity may serve to surmount the limits of the painted canvas and better approximate the visual impression made by the scene itself. Most of the further massive deviations from projective fidelity that we consider in relation to the representation of space follow similarly from the inherent limits of the flat pictorial surface, making the representation itself an art rather than an exercise in geometry.

C. The Perceptual Issues in Spatial Representation

Let us start again, at what served as the starting point for much of philosophy, art theory, and psychology, and assume that the trompe l'oeil picture and the scene it represents both act on the eye in the same way. An infinite number of arrangements will do the same, by an argument that is surely familiar at least since Bishop Berkeley: one cannot specify three dimensions with only two.[3]

[3] The fact that a flat picture can act as a surrogate for 3-D objects at different distances was early taken to show that we cannot perceive depth directly: Alhazen in 1572, Peckham in 1504, as described by J. White (1967, pp. 126, 129). Developed fully by Berkeley, in 1709, and thence through James Mill, John

Of that infinity of scenes, why does one perceive only *that* scene which the artist intended to represent? Also (and this is why pictures and depth so interest philosophers, psychologists and roboticists, alike), why does one see the world when all that is given is a necessarily ambiguous retinal image, one that can in principle be fooled by an infinity of interchangeable pictures and scenes?

The *classical* answer was that depth is seen in the real world only because humans have learned to associate visual depth cues (da Vinci's, plus others) with the tactual-motor experiences received in the course of dealings with the three-dimensional (3-D) arrangements of the world. Two aspects of this classical answer are important here. The first is that because these cues normally mediate our seeing of the world of space and objects, *it required no new explanation to account for pictures.*

In the second important aspect of this line of thought that evolved from Berkeley to Helmholtz, the observer supplies necessary *mental structure:* This object looks further away *because* the lines in the retinal image seem to converge, and appears larger *because* (with a given visual angle) it appears farther away. *The physical rules of the visual ecology have been incorporated in the perceptual habits of the viewer;* all depth cues are learned, and what makes each effective is its prior association with other depth cues and with the moving, reaching, and touching that the viewer's history has furnished. Although there may be occasional errors in the perceptual structures fitted to such sensory patterns, probablistically they will be right more often than wrong (see Brunswik, 1956).

To Gestalt psychologists, the determinants of perception are the laws of organization, not ecological probabilities (except as the latter have constrained our evolution). According to Gestalt theory, one sees the simplest or most homogeneous image that will fit the pattern of stimulation. In fact, most of the classical pictorial depth cues can as readily be treated as examples of simplicity as of familiarity (Hochberg, 1974b; Hochberg & MacAlister, 1953). Because Gestalt theory sees representation as a result of innate brain-field organization, not of perceptual habit, both the main features of space perception, and of picture perception (following the same laws of organization), should hold for any viewer, regardless of his or her experience with pictures.

In what Gestaltists (and many others since Rubin's observations) take as the basic phenomenon of visual perception, the *figure* is an area that's shape is recognized (marked *f* in Fig. 2B), whereas the ground is shapeless and usually farther back, extending beyond the figure (Koffka, 1935; Woodworth, 1938). What will be perceived as figure (and consequently, what will be perceived in a picture) presumably depends on the so-called laws of organization, and not on familiarity

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Stuart Mill, and Hermann von Helmholtz, this argument remains part of the psychologist's somewhat battered infrastructure. Although followers of Gibson sometimes retort that the additional dimension of time restores a third dimension to the retinal image (by introducing movement-based optic flow), one cannot specify four dimensions with three any more than three with two, as moving pictures attest.

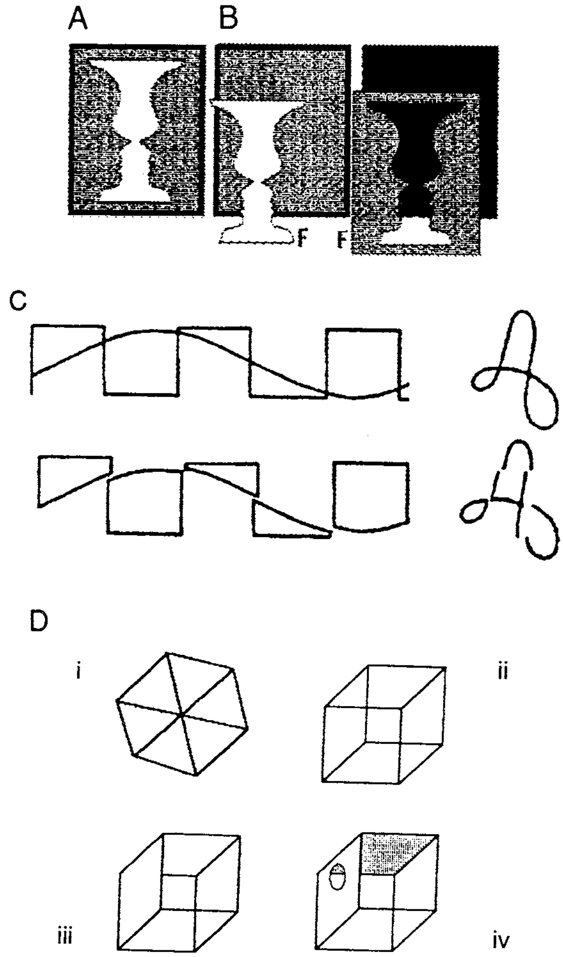


FIGURE 2 (A) At left, a reversible (ambiguous) figure–ground pattern. (B) At right, two alternative shapes that can be seen as figure in A. (C) By the "law" of good continuation, the upper-left pattern should be seen as a sine wave crossing a square wave, not the set of closed shapes that are seen in the lower-left pattern; similarly, no "4" should be visible in the upper-right pattern (as it is at lower right). (D) Figures at i and ii look 2-D and 3-D, respectively, presumably because good continuation (and other Gestalt factors) favor those organizations (Kopfermann, 1930); or perhaps because of a *minimum principle,* that we perceive the simplest overall structure. The latter can be phrased objectively, and also explains de Vinci's depth cues (Hochberg & Brooks, 1964; Hochberg & MacAlister, 1953). But when viewers fixate the ambiguous lower-right intersection in iii, it undergoes spontaneous reversal, in conflict with the upper-left intersection (Hochberg, 1970; Hochberg & Peterson, 1987), or with as many more intersections as we wish (cf. iv), making any object-wide minimum principle, or any other organizational theory which does not define its span of application, currently unviable.

(as Helmholtzians might assume), because meaningless figures may predominate over meaningful ones (e.g., the "4" is concealed in Fig. 2C through the operation of the "law of good continuation"), a point I will shortly question.

Manipulating drawings so as to discover what makes a particular area's shape be seen as a figure, and what causes it to become unrecognizable ground, is therefore a convenient and rapid way to discover what the laws of organization are. It is also a way to help the artist make pictures that will be perceived as desired (e.g., as a visible figure rather than unshaped ground) (Fig. 2A,C), or as 3-D rather than flat (Figs. 2Dii, i, respectively).

It also implies that producing the same pattern of light to the eye as does the scene itself does not ensure that the viewer will see the scene as it really exists. Any snapshot in which a flowerpot seems to be growing out of the subject's head shows how violations of Gestalt laws (again, good continuation, in this case) can make even the most perfect surrogate unveridical or even unintelligible. The Gestalt laws therefore seemed immediately relevant to artists, whose theoretical and graphic concern with the mechanisms of making things be seen one way or another are easy to find (e.g., Matisse's *Dancer,* Tchelitcheff's *Hide and Seek;* Arp's reversible amoebas; and the figure-ground exercises of Escher and Albers). Expression and feeling were held to be just as directly given in the field forces that the configuration engendered in the brain as is the shape itself. Arnheim's important and influential essays and books on the psychology of art, written by a Gestalt psychologist, seemed far closer to what artists were concerned with than any psychophysical treatment had been (see Arnheim, 1954, 1966 for a summing up of that viewpoint).

More objective formulations of the laws of organization were attempted, and usually referred to something like information theory rather than to brain-field organization (cf. Attneave & Frost, 1969; Hochberg & Brooks, 1960; Leeuwenberg, 1971).[4] I will discuss later why both the Gestalt approach and these variants may be useful only as very rough practical approximations, and why it would be a mistake to take them seriously today, either as theoretical explanations of picture perception or as generally viable perceptual approaches (see Fig. 2Diii, iv; cf. Peterson & Hochberg, 1989).

James J. Gibson argued that neither Helmholtzian mental structure, Gestalt organization, nor any other information contributed by the viewer is needed to explain perception in general and depth perception in particular: The information in the proximal stimulation, he argued, is sufficient to account for the direct, correct (veridical) perception of the surfaces and objects of the world. The percep-

[4] Despite the many books for artists that introduce the Gestalt philosophy and demonstrations, a cookbook on their application to pictorial intelligibility remains at once potentially possible, clearly desirable, and essentially unwritten. The possible effects of ground (the space *between* the shapes) as a factor in composition has long been raised in connection with the theory of design (cf. Taylor, 1964) and should theoretically be quantifiable in that regard, but research on this matter has not been done.

tion of such components of the layout as surfaces, edges, corners, and so on, he claimed, is directly specified by higher order variables of stimulation, like texture-density gradients and, above all, by the wealth of optic flow in the light to the eye that results from viewers' movements through a 3-D world. The pictorial depth cues as studied since da Vinci are not the basis of our normal perception of the real world, and the phenomena displayed by artificial preparations such as the scribbles on paper conveying the geometrical illusions and the Gestalt grouping principles, are nondiagnostic for normal perception.

These claims are inconsistent with the nature of pictures, however, because even a high-fidelity picture lacks the motion-produced information that specifies 3-D objects and spaces, whereas it surely provides the motion-produced information that it is a flat pigmented surface, and that the depth cues are thereby specified as being flat markings on that surface. In general, although Gibson has worked at a solution to this problem (Gibson, 1950, 1951, 1954, 1966, 1971, 1979), and others following his approach have made contributions to our understanding of the nature of picture perception (Hagen, 1974, 1976; Kennedy, 1974, 1977, 1993; Sedgwick, 1980, 1983, 1991), I think pictures remain an unresolved and critical problem within his approach. If the cues used in perceiving artwork and illustrations, both ancient and modern, are not also used in perceiving the world, how does it happen that those cues work in pictures?

First, I should note that there is at least some evidence that the static pictorial depth cues do indeed affect perceptions of space and movement even in the case of real, moving objects and viewers (Hochberg, 1987), and then produce illusions of concomitant motion (p. 236n) due to the accompanying parallactic displacement: Gogel & Tietz, 1992; Hochberg & Beer, 1991. Moreover, pictorial depth cues within a single picture may elicit binocular convergence appropriate to the depth they depict (Enright, 1991). Indeed, the classical geometrical illusions, such as the Müller–Lyer, which have traditionally been discussed in terms of line drawings, are also obtained with moving observers and solid objects (see DeLucia & Hochberg, 1991; Hochberg, 1987). These facts contradict the Gibsonian assertions that perception is veridical under normal seeing conditions and that therefore results obtained with drawings are not diagnostic of more general perceptual processes. It also seriously weakens the most common class of explanations of these illusions, which is that the illusions result from misapplied constancy scaling of pictorial depth cues (Gillam, 1978; Gregory, 1970).

Second, and fairly conclusive, there is the central fact that no training at all beyond that given by experience in the world itself is needed to recognize the things that are represented by at least some pictures, including line drawings like those in Figure 3 (Hochberg & Brooks, 1962a), a clear experimental answer for which there is also some anthropological support (Kennedy, 1977). Picture perception is *not* an arbitrary conventional skill, like reading: If its elements are learned at all, they are learned by commerce with the real world. We will return to this point later. Whatever causes viewers to take outlines as equivalent to objects' edges, it is

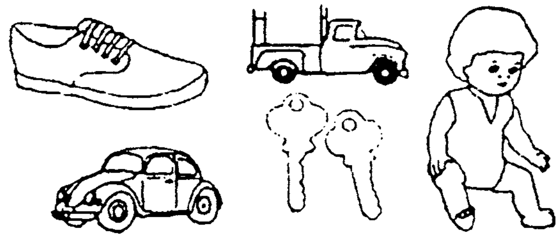


FIGURE 3 Outline drawings correctly identified by a child who had received no prior pictorial training.

not "symbol learning," and *it cannot be unrelated to how humans see the world itself.* That pictures drawn in outlines (i.e., in ribbons of pigment on paper, Gibson, 1951) are recognized naturally as objects, is a phenomenon that must *reflect an attribute of the viewer, not of the light at the eye.*[5]

Pictorial education does seem to improve the ability to interpret distance and size relations in pictures (Hagen & Jones, 1978; Krampen, 1993; Olson, 1975; Willats, 1977; Yonas & Hagen, 1973), particularly in highly impoverished pictures: As their experience with Western pictures increased, native Africans were better able to perceive spatial arrangements in pictures with sparse and somewhat ambiguous linear perspective (Hudson, 1962, 1967; Kilbride & Robbins, 1968; Mundy-Castle, 1966), although those results have been questioned on various theoretical and empirical grounds (Deregowski, 1968; Hagen, 1974; Hochberg, 1972b, p. 501; Jahoda & McGurk, 1974; Jones & Hagen, 1980; Kennedy, 1977; Omari & Cook, 1972). And an improvement in "reading" outline objects may reflect the older child's greater ability to perceive a line as belonging to more than one shape (Ghent, 1956) and to perceive an object for which only partial outlines are given (Gollin, 1960).

In two other major ways, projective fidelity is insufficient and unnecessary for representing objects and their attributes in pictured space. The first problem concerns viewpoint independence. An optically correct surrogate has, in general, only one viewpoint from which it fits the light from the scene it represents. When pictures are displayed, however, virtually no effort is made to have them viewed from the *one* point that their projective geometry dictates, even though the 3-D layout that can be fit to the two-dimensional (2-D) pattern differs with each viewpoint. Pirenne (1970) argued that the picture remains effective because we compensate for the slant of its surface, of which we are aware because of its frame, its texture, binocular parallax, and so on. That is, we presumably take that slant into

[5] As Hochberg and Brooks noted in 1962, these findings show that *lines must share some stimulus property with edges.* In Hochberg (1962) I thought primarily of luminance differences related to depth and light, but Kennedy (1974, 1993) has carried the problem considerably further.

account when arriving at a perception of the pattern that lies upon it. Something like that compensation does indeed seem to occur, but as will be argued it cannot be the whole story.

The second problem is posed by artists' deliberate violation of projective fidelity: Even while diligently using vanishing-point perspective, artists present certain objects (especially familiar ones) as though their main surfaces were always parallel to the picture plane, regardless of the object's depicted orientation. This distortion, which includes da Vinci's "synthetic perspective" (J. White, 1967, pp. 209–215), is used to overcome a problem that arises in the way we perceive optically correct pictures that are viewed from nearby.

This problem arises because the picture, being flat, is not equidistant from the eye, and the distance differences are significant when the picture is not far off (Fig. 4). Figure 4B is in *incorrect* projection, with each sphere pictured from straight ahead (essentially da Vinci's synthetic perspective), but looks more correct even when viewed from E. There are serious cognitive issues here, which we consider in turn.

Because of the widespread violations of perspective in the viewing and making of pictures, Nelson Goodman (1968) took perspective and pictured depth as arbitrary conventions, learned from pictures: Pictures, in this general view, are a visual language invented by artists (Kepes, 1944), cultural artifacts that in turn determined our nonpictorial vision (Wartofsky, 1979).

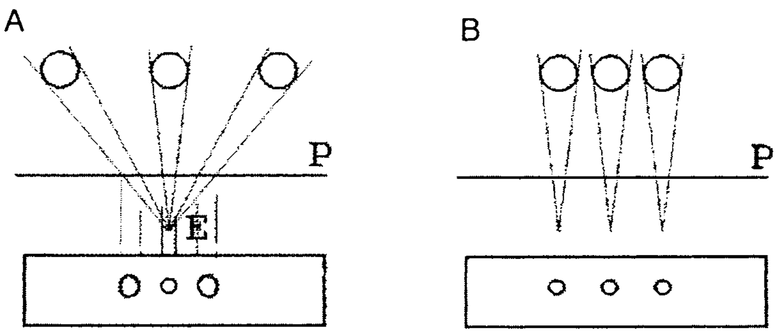
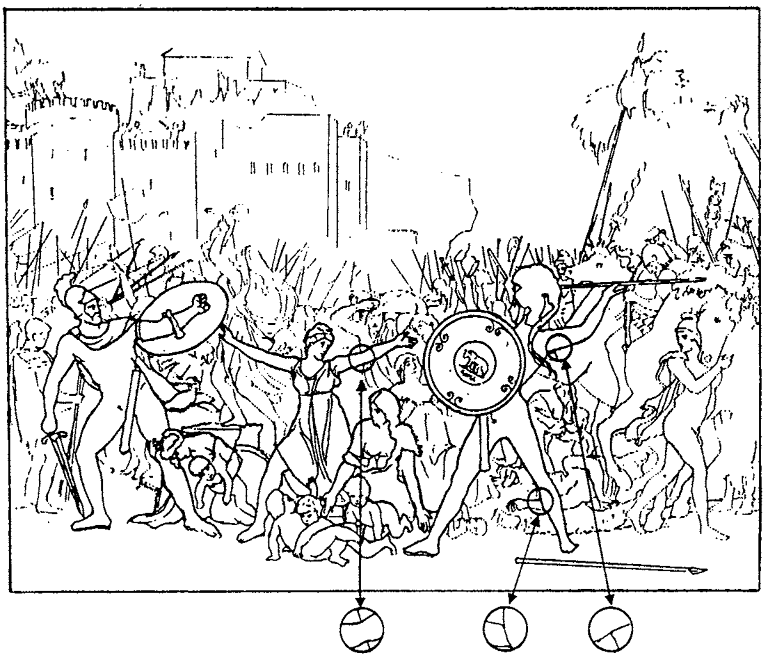


FIGURE 4 (A) Shapes projected on a near picture plane (P). When *correctly* projected as viewed from E, the three spheres at the top are shown as they would be traced on P (all here shown from above); the resulting picture is also to be viewed from E, and is shown in the lower sketch. Note that the pictures of the two outer spheres are larger than that of the center sphere, and somewhat distorted, as they must be if they are to project the same image to the eye. (B) A common distortion in projection that looks more correct than the correct projection at A. In Pirenne's (1970) explanation, viewers compensate for perceived slant to the line of sight in A, thereby correctly seeing that the shapes on the picture's surface are distorted, whereas in B the compensation for the slant yields undistorted pictures of the objects' shapes. (C) A sketch of one of David's large realistic exhibition paintings, made to be viewed from nearby, with all objects painted as in B and with virtually no perspective. (Modified from Hochberg, 1984.) (D) A sketch of a Cézanne painting, showing that at most of the intersections (b–e) good continuation has evidently been used to weaken interposition in foveal viewing.

C



D

FIGURE 4 Continued

This position has many close relatives in modern writings on literature and film. It also has its critics,[6] and it is wrong: Perspective is not arbitrary geometrically (see Gombrich, 1972b; Pirenne, 1970; Sedgwick, 1980, 1983, 1991). As I have just shown, when "realist" artists distort perspective, that distortion itself is usually an attempt to deal with the conflicts between the picture's flatness and the signs of depth it specifies. (Or it may be a specific effort to evoke an eerie, unresolvable, and highly notable conflict, as in de Chirico.)

Moreover, perspective is only one somewhat esoteric pictorial depth cue, among others much older, such as *interposition* and *modeling.* Perspective is global, applying to the entire scene depicted, and it is potentially *metric,* signifying not only that one object is farther than another, but how much farther it is. Other major depth cues are local and nonmetric (in this being like diagonality, a local consequence of perspective: see Gillam, 1978). Interposition, for example, heavily used for centuries in many cultures, is (most simply stated) that the uninterrupted line or contour bounds the nearer surface; there are several related cues as to local spatial structure that are offered by intersecting or interrupted lines or contours (Guzman, 1969; Hochberg, 1994; Kellman & Shipley, 1992; Ratoosh, 1949). It is ordinal rather than metric in the depth it signifies, and is therefore far less vulnerable to changes in viewpoint; and it is local, and therefore does not require the viewer to assess the agreement of distant lines and patterns, which generally seems to require specific effort.[7] Modeling or shading is provided by the light reflected to the eye from diffusing surfaces at varying orientations to the line of sight (for analyses see Horn, 1981; Todd & Mingolla, 1983). Although this cue is good for signifying whether the surface is curved or not curved, the *amount* of curvature perceived is not well represented (Todd, 1989; Todd & Reichel, 1989).

Because of its limitations, many artists have therefore avoided global perspective entirely, as in David's wide paintings (e.g., Fig. 4C). These are highly realistic extended exercises in interposition, in modeling through shading (see footnote 8), and in da Vinci's synthetic perspective (compare Figs. 4B and 4C). Designed to be viewed from nearby and from many different standpoints during commercial exhibition (Brookner, 1980, p. 139), these sidestep the viewpoint problem by using virtually no linear perspective. This was an early and widely used solution (Söström, 1978).

In fact, even interposition has been rendered depthless to foveal vision, as when Cézanne (Fig. 4D, dated 1866 and hanging in the National Gallery, Washington, DC) substitutes a smoothly continuing curve for the abrupt intersection without making the picture's subject unrecognizable (for analysis and comparison to the David painting, see Hochberg, 1984). This method for disarming interposition

[6] For example, Carrol, 1988; Gombrich, 1972; Tormey, 1980; Wollheim, 1987.

[7] The perspective information in a scene may require comparison over large distances, which we will see is not necessarily available to the viewer within a single glance (p. 172f), and which indeed Arnheim (1966) has said is confusing to the uninitiated.

locally is easy to find as well in Matisse, Vuillard, Morisot, and others (Hochberg, 1980, 1984). The use of this method suggests that these artists consider interposition a foveally effective cue that is not essential to recognizing the represented object.

I must take the argument further: Artists in all cultures and at all times have felt free to use *no depth cues at all.* (Except, of course, to the extent to which outlines act as edges, at which one surface occludes the background behind it.) Although the pictorial depth cues are not arbitrary conventions, and can evidently contribute to the perception of both pictured and real depth, there is no reason to assume that the representation of recognizable objects depends in any way on the explicit representation of depth.[8] Remember that in Figure 3, no depth cues were present or needed.

Let us now review these points in the context of perceptual and cognitive theory and research. First, the idea that one compensates for differences in distance or for the slant of the picture's surface, and only then arrives at perceptions of the pictured space from those corrected shapes, implies that viewers use unconscious inference—calculations based on unconscious knowledge about the geometrical couplings of size and distance, slant and shape, in the optics of the physical world (Hochberg, 1974a). The issue therefore has theoretical weight. Is there strong evidence that compensation occurs and is needed? The issue remains open. The geometry of the virtual spaces that would optically fit any given picture certainly changes with viewpoint (see Farber & Rosinski, 1978; Lumsden, 1980; Rosinski, Mulholland, Degelman & Farber, 1980; Sedgwick, 1991). With perfect compensation, the 3-D layout perceived in any picture would not change as the viewpoint changes.

There are laboratory studies that have found that viewpoint has no effect on pictured objects' apparent sizes (Hagen, 1976), on their apparent slant (Rosinski, Mulholland, Degelman, and Farber, 1977), or on their apparent forms (i.e., their rectangularity or nonrectangularity: Perkins, 1973), except at extreme viewing angles. Most of these researchers concluded that some degree of compensation for picture plane must occur. That may be true, but one should note that the thesis that virtual space is mediated by compensation-corrected 2-D pictorial information is

[8] Most analyses by psychologists and computer scientists of how we perceive the world and pictures of it have assumed that objects are seen as surfaces or volumes in 3-D space, defined by their coordinates relative to the viewer (i.e., the distances and orientations at each point in the field of view) (Gibson, 1950; Horn, 1977; Marr, 1982). Admittedly, it is true that viewers can recognize volumetric objects, with no outlines present, defined only by the binocular disparities of the dots in a random-dot stereogram, and by the modeling, shading, and texture in a picture. But although shading effectively distinguishes a flat from a curved surface (Cutting & Millard, 1984), viewer's judgments are unreliable (Stevens & Brooks, 1987; Todd & Akerstrom, 1987), and it seems likely that shading and texture can normally provide only ordinal, nonmetric perceptions of surface orientation (Todd & Reichel, 1989). In such surfaces, viewers use the information given by contours formed at folds or occlusions in the surface (i.e., what amount to outlines) very well. And in any case, however, we know that surface modeling and binocular disparity are not normally essential to the recognition of pictured objects.

not strongly proven. Whatever compensation there may be is certainly not complete over the range of possible viewing conditions: With nearer or farther viewing, as all artists and photographers know, the depth and size perceived within the picture do vary, at least roughly as they should in the virtual space that fits the picture. An anamorphic picture that is recognizable when viewed at the appropriate extreme slant may be unrecognizable when the picture is normally viewed (Clerici, 1954), but this might be true precisely because the "appropriate slant is extreme and compensation fails.[9] Changes toward what one would expect from the geometry, however, are reported anecdotally to occur under much more normal pictorial viewing conditions (e.g., Gombrich, 1972b).

They also have been measured experimentally in laboratory situations: Within a picture's represented layout, the viewer's perceptions of shapes, slants, directions, and distances (Smith & Gruber, 1958) vary at least qualitatively as one would expect from the projective geometry and the viewer's location relative to the picture. Nor is there reason to believe that a given picture is locked to a given virtual space. Thus, when Goldstein (1979, 1987, 1991) had viewers reproduce the layout of poles represented in Figures 5A and B, they showed almost perfect constancy for viewing angle by producing almost identical layouts; but when asked how the poles were aligned relative to the picture plane, viewers' results changed in what Cutting (1988) showed was good agreement with the projective geometry, thus showing little or no compensation. The fact that different questions about the virtual space provide different answers certainly shows that the virtual space that viewers perceive with pictures does not have the invariant properties specified by the optical geometry of the surrogate theory.

That the picture itself (as well as the layout being represented) may appear largely unchanged from different viewpoints does not itself demand Helmholtzian inference (Hochberg, 1971, 1978). The ratios of textural units subtended by the different parts of any shape on a surface that is slanted to the line of sight would remain invariant (Gibson, 1950), and the kinds of distortion that result from viewpoint changes (Farber & Rosinski, 1978) would leave such ratios invariant along any dimension considered separately.

Furthermore, perhaps the distortions are perceived, but go unattended because the objects being depicted remain fully recognizable—identifiable—over a wide range of distortions (Hochberg, 1971, 1978), and thereby define the contents of the picture.

The fact is that any compensation theory in which the perceiver fits a model of physical space that is geometrically dense and consistent has long since been effec-

[9] Anamorphic pictures were traditionally made to be too distorted to recognize when the picture plane is viewed from within a normal range of slants to the line of sight, but to become recognizable when the picture is viewed from the appropriately extreme slant (e.g., the skull in Holbein's *The Ambassadors*). If that slant were then compensated, the anamorph should remain unrecognizable. Familiarity seems to be a factor, and such distortion should provide a psychophysically manipulable variable for studying object perception.

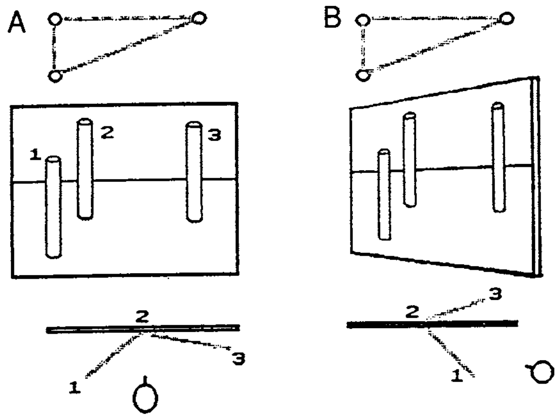


FIGURE 5 (A) a picture of 3 rods in space is looked at from in front, its canonical viewpoint; (B) it is looked at from near its right edge. The triangles over each picture show viewers' judgments of the poles' layouts in depth; the shaded lines connecting 1, 2, and 3 below each picture show viewers' judgments about the rods' alignments with respect to the picture plane (here viewed from above). The two spatial tasks do not yield the same judged 3-D layouts (modified from Goldstein, 1987).

tively ruled out both by artistic practice and laboratory research. Pictorial inconsistencies have been deliberately used, and are tolerated or even unnoticed, since at least the introduction of da Vinci's synthetic perspective. Indeed, it has been reported that viewers judge objects drawn in parallel perspective (which would, of course, be incorrect except when viewed from infinity) to be both more realistic and more accurate than those drawn in the converging perspective that would be correct for their viewing position (see Hagen & Elliott, 1976, a study that has been criticized by Kubovy, 1986, but a conclusion with which I find it hard to disagree).

More direct evidence to the same point is the fact that pictures of inconsistent or impossible objects are not automatically perceived as such. Escher's pictures (and some of Piranesi's), those of Albers, and the demonstrations by Penrose and Penrose (1958) and Hochberg (1968), offered pictured objects that would be physically impossible as 3-D structures but are not clearly seen as much, nor are they seen as complex 2-D drawings, which a Gestalt or informational minimum principle (Fig. 2Di, ii) should argue. Indeed, perfectly possible objects may be perceived as objects that are impossible in this sense (Gillam, 1978; Hochberg, 1970). For example, in Figure 2Diii depth reverses spontaneously when viewers fixate the ambiguous lower right intersection (Hochberg, 1970; Hochberg & Peterson, 1987; Peterson & Hochberg, 1983), so both global minimum principles and likelihood principles are unviable in anything like their present forms (Hochberg, 1982; see also Hochberg, 1987).

Such pictures show that each glance obtains only a limited part of the depth information within the object or picture, and that the overall cognitive structure resulting from those glances does not automatically test for internal consistency. At least two separate levels must therefore be considered to be at work in the perception of objects and scenes: the local features (or local depth cues), such as those offered by the intersection being viewed foveally, and some aspect of the global pattern as currently visible in the low resolution of peripheral vision or as carried in working memory from previous viewing. Without a deliberate effort to *attend* to the mutual spatial relationships specified by the individual glances at difference features, much of the information potentially offered by the layout (spatial and otherwise) is without perceptual consequence (Hochberg, 1968, 1970, 1982). Without good reason to believe otherwise, it seems plausible that these observations are true of pictures quite generally, and apply not only to reversals of near and far but to degree of depth. While attending to a region in which depth differences are small or nonexistent, the differences between picture and the three-dimensional scene it represents may also be small or even rendered nonexistent.

I think that many artists have either by explicit thought or by trial and error taken these considerations into account (see Hochberg, 1980). Avoiding a textured background near the sitter's cheek, using *sfumato* (blurring edge contours) and chiaroscuro to keep attention to such regions as would not offer substantial depth differences in the real object, can provide significant perceptual intervals in which the picture does not force the viewer to note that it lacks the object's solidity. A flat picture may therefore look similar to its three-dimensional subject simply because under many viewing conditions the recognizable features of the latter provide the stationary viewer with little depth information that is important to the object's recognition and appearance (Cutting & Vishton, 1995; Hochberg, 1980). What we perceive is not determined by what distal properties the stimulus information specifies physically. I will go further, in Section IID, and argue that there is simply no support for a surrogate theory of pictures which rests on physical definitions of pictorial fidelity, nor any need for such an account of pictures. There is however need for some account of the process that elects and guides the viewer's glances, and that achieves some integration of their contents.

Let us consider those issues first, and then their relationship to the nonrepresentational functions of visual art.

D. Perception as Purposive Behavior: Schemas, Canonical Forms, and Caricature

When one looks at a picture, one does not (and cannot) direct the eyes everywhere; and even if one did scan a picture in a complete raster (which would take same 200 glances and at least a minute of rapid eye movements to sample an 8 × 10 picture in 4° foveal glimpses), there is no reason to assume that everything would be automatically stored and stitched into a single perceived pattern that contains all the extended information that is physically present in the field of view. The latter, or *optic array,* is therefore not a realistic starting point for discussing the nature of visual processing.

In laboratory studies, subjects look first at regions that are most likely to be informative (by subjects' ratings or by experimenters' definitions [Antes, 1974; Hochberg & Brooks, 1962b; Loftus, 1976; Mackworth & Morandi, 1967; Pollack & Spence, 1968]) and that touch on the main features of the composition as it would be described from a design standpoint (Bouleau, 1963, Buswell, 1935; Molnar, 1968). One can detect large features in peripheral vision while focusing attention on detailed foveal information (Braun & Sagi, 1990), but detailed inquiry must proceed one glance at a time. These acts of looking can therefore be guided by low-resolution peripheral vision, aided by the redundancy of normal scenes and pictures. (A clear demonstration of such redundancy is that a particular object can be located faster when it is in a normal, appropriate scene than when it is in a jumbled or inappropriate one—Biederman, 1972).

One therefore looks at pictures (and at the world) piecemeal. Perceptions must fit that set of limited glances (Gombrich, 1963, 1984; Hochberg, 1968) that are free to continue at length or to terminate after only a very small proportion of the visual field has been brought to detailed foveal vision. *Because glances are purposeful, elective actions, one cannot in advance say what parts of the information in the light offered to the eye by picture or world will in fact be sampled.* Because of the occlusions that are routinely offered in a normally cluttered scene, one must ignore some information that is actually present and add information that is absent in order to achieve a rememberable encoding of what was sampled. Between stimulus description and final perceptual consequence one must therefore posit and investigate mental structures—schematic maps (Hochberg, 1968) or hypothesized objects (Gregory, 1970, 1980)—that serve essential perceptual functions. They motivate successive glances of perceptual inquiry, guide the acts by which the questions are answered, serve as the criteria that terminate the inquiry, and provide for storing the results of the inquiry.[10]

This metatheory is an old one and widely held,[11] but very little is known about the mental structures by which successive glances are integrated, and only a little more is known about what motivates the perceptual inquiry that drives those glances.

The overall view perceived from a series of glances is not constructed by serial integration (i.e., by taking the successive eye movements into account); rather, the

[10] The part that schemas play in remembering verbal narrative, dramatically demonstrated by Bartlett in 1932, is here filled by a structure of contingent visual expectations. An example of such visual expectations might be expressed in words as follows: Is this blurred object a car or a cat? If this is a car, I must look over there to see if it has a headlight. It has a headlight, so it is a car and not a cat, and there is no need to look further: it was a car. In the case of verbal narratives, the listener or reader often consults only local context, rather than the overall story schema (Dosher & Corbett, 1982; Glanzer, Fischer, & Dorfman, 1984; Mckoon & Ratcliff, 1992), even though that structure may be called upon when needed. The visual phenomena discussed in connection with Figure 4 may display the visual counterpart of that looseness.

[11] Really a version of the Helmholtz–Hebb position, and essentially also that of Neisser (1967), it was fairly explicit in J. S. Mill and Helmholtz near the turn of the century.

relative locations of features remain more or less unchanged in the mind's eye despite the shifts in gaze, and probably provide the invariant framework within which each rememberable feature takes its place (Gibson, 1950; Haber, 1985; Irwin, Zacks, & Brown, 1990).

Given that the structures perceived in response even to real or represented objects that permit a perfectly consistent and physically possible construal may nevertheless be quite different, (i.e., physically inconsistent or impossible), it seems safe to assert that the process by which successive glimpses are stored does not follow physical constraints, despite the traditional assumption that perceptual structure reflects physical structure (as in Gregory, 1980; Rock, 1977; Shepard 1984). The perceiver's tolerance of the kind of inconsistencies we have noted, and of many other kinds that can be discovered in any but the most realistic surrogate, argues that the overall structures do not necessarily intrude in the interpretation of each foveal detail. As in verbal story schemes, the overall structure is not automatically consulted at each point (see footnote 10). The same effects occur with real moving objects, showing again that at least some phenomena of picture perception do reveal the nature of more general perceptual process.[12] From this viewpoint, outlines may act like objects' edges because they share the same mechanisms at one or more levels of perceptual processing.

This would surely be adaptive, given the nature of visual inquiry: The eye has the wide field of peripheral vision as a form of on-line storage, a very impoverished reminder of where the fovea had been directed and a preview of what it might find at other loci in the field of view. With their low resolution (no detail, no texture, etc.) peripheral views of the real world and of its pictures must differ little from each other, and the contours at objects' edges, corners, and occlusions must be most important. As noted in Figure 1, the individual glance is limited in the detail it can carry forward; the periphery has an even more limited sensitivity to the detail that has been (or might be) brought to the fovea; and some reduced framework or schema is needed to relate the glances by which we sample both world and picture. Outline drawings seem able to activate such schemas and maps, both in vision and more generally.[13]

[12] For example, a real, 3-D version of Figure 2Diii works in the same way, whether it or the viewer moves (Hochberg & Peterson, 1987), appearing to rotate in illusory motion when it is seen in the wrong spatial arrangement.

[13] As in recognizing an object by touch, which requires haptic exploration and an integrative image (see Klatzky, Loomis, Lederman, Wake, & Fujita, 1993; Lederman & Klatzky, 1987), the foveal exploration of a scene or picture takes time and storage (Hochberg, 1968). But the eye has the wide field of peripheral vision as a form of on-line storage, a very impoverished reminder of where the fovea had been directed and preview of what it might find at other loci in the field of view. With their low resolution (no detail, no texture, etc.) peripheral views of the real world and of its pictures must differ little from each other, and the contours at objects' edges, corners, and occlusions must be most important. As noted in Figure 1, the individual glance is limited in the detail it can carry forward; the periphery has an even more limited sensitivity to the detail that has been (or might be) brought to the fovea; and some reduced framework or schema is needed to relate the glances by which one samples

And perhaps other basic perceptual phenomena may flow from the same conditions: The term *object,* as used here, refers to whatever maintains some relatively fixed structural relationship between its parts, regardless of how its movements (or viewer's movements) place it in the field of view. (Other questions of phenomenal identity arise within short-range apparent motion (see Chapter 6, this volume) but they are sidestepped here.) The viewer needs to know in advance where in peripheral vision there lies an object. Perhaps the figure-ground phenomenon (Fig. 2) reveals where one expects the eyes to find objects' edges, and which side will be the occluding surface: that is, perhaps the Gestalt laws are object cues—cues as to which side of an edge is part of the object, and which parts of the visual field will move together as a unit when moving heads or eyes.[14]

Some object cues are less ambiguous in this way than others (e.g., intersections and corners [Guzman, 1968; Hochberg, 1968; cf. Ratoosh, 1949]), although none absolutely foreclose alternative construal (Chapanis & McCleary, 1953; Dinnerstein & Wertheimer, 1957; see Hochberg, 1994). Most objects display those cues, and the distinctive features that identify those objects are better from one viewpoint than another. Given some arbitrary viewpoint (e.g., a random photograph), it is unlikely that the most informative and characteristic features will be presented as economically and effectively as an artist can choose to combine them, especially *given that the artist is free to change viewpoint within a single object at little cost* (as discussed previously). An object in what may be called its *canonical form* (Which best displays its characteristic features; see Hochberg, 1972a), may offer the viewer a prototype that may help in encoding and storing similar objects in the future (cf. Attneave, 1957a; Gombrich, 1956, 1972b).

If properly constructed, therefore, cartoons and caricatures, despite their drastic

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both world and picture. Outline drawings seem able to activate such schemas and mental maps, both in vision and more generally: Thus, raised drawings, explored hapticly, work at least to some degree with blind subjects (Kennedy, 1993; Klatzky et al., 1993), who are able to form what amounts to schematic maps of spatial layouts (Arnheim, 1990; Haber, Haber, Levin, Hollyfield, 1993; Landau, 1985).

[14] For example, the law of good continuation is a case of interposition, in the sense that it is extremely unlikely that two different objects, at different distances, will line up within the tolerances of our excellent ability to distinguish misalignments (Hochberg, 1962, 1972b); the law of proximity reflects the fact that things that are close together are more likely to be part of one object (Brunswik & Kamiya, 1953). The first factor should serve both foveally and peripherally, the second would seem more useful in peripheral vision.

Such speculations seem plausible to me, but not enough is now known about the information contributed by peripheral vision to make them testable and applicable. Effective resolution falls off steeply outside of the fovea, as does spatial information (whether through spatial undersampling or perhaps through poor spatial calibration; Hess & Field, 1993). Ginsburg (1980) phrased a speculative description of the Gestalt phenomena in terms of low spatial-frequency filtering, which is one way to achieve a low resolution version of any scene or picture. Still missing is any systematic demonstration that such an account captures the characteristics of what peripheral vision contributes to the succession of combined foveal and peripheral views by which scenes and their pictures are sampled in the course of elective eye movements.

loss of information and fidelity, may better serve to represent the world, clarify visual relationships (cf. Arnheim, 1969), and effect our thoughts (Gombrich, 1956) than pictures of high fidelity. The pioneering work of Ryan and Schwartz (1956) showed that the layouts of at least some objects were better communicated by cartoons that had intentionally been made to help viewers retrieve the information that the task called for than by photographs, shaded drawings, or outline drawings. Some of the generalizations subsequently attributed to that study have been questioned (Biederman & Ju, 1988; Tversky & Baratz, 1985), and experimental research has failed to find caricatures of people superior to their photographs (Tversky & Baratz, 1985), but we do not yet have a principled basis for knowing how to fit the specific caricature to the needs of the specific recognition task.

It would be of great theoretical and applied interest if some finite number of object cues, learned from the real world but applicable to pictures as well, could be found to account for a significant amount of pictorial recognition. One of the problems with the assumption that an object is perceived in terms of the 3-D surface distances specified by its optical projection is that each slight change in viewpoint provides a very different set of such specifications for the same object. The seminal step away from the assumption was taken, I believe, in 1954, when Attneave showed, originally using a guessing-game procedure, that the inflection points in a silhouette or outline carry the (potentially measurable) load of the pictorial information and meaning. It is important to note that the relative placement and topology of these features as they meet the eye in the 2-D optic array (or in a picture) are relatively independent of the 3-D object's size and slant to the line of sight. Note too that in Hebb's (1949) enormously influential synthesis of the classical and Gestalt approaches, embodied today in most connectionist models of computational neurophysiology, the frequently encountered components of objects in the visual environment are taken as the primitives of perception (the *cell-assemblies*). It is by the 2-D arrangement of these components, not by their 3-D structure in depth, that objects and other familiar shapes are recognized.

Proceeding along this line, it would be more effective if viewers (whether humans or devices equipped with computer vision) would analyze outlines into those features that are relatively independent of viewpoint; for example, a rectangle in the field of view is unlikely to be projected there by a nonrectangular trapezoid.[15] Pictorial object recognition based on such features would be relatively unaffected by viewing angle, with no need to assume a compensation process.

For such an approach to have applied and theoretical consequences, we need more specific knowledge about the features by which objects are distinguished and recognized.

Until relatively recently, the framework for most perceptual theories was essen-

[15] Such *nonaccidental* properties are discussed by Biederman, 1985; Binford, 1971; Hoffman and Richards, 1985; Kanade and Kender, 1983; Lowe, 1985; and Richards and Hoffman, 1985. Actual application of these in pictorial perception has not been tested.

tially that of geometrical optics or retinal configurations. If instead (or in addition) object familiarity is taken as an important source of visual primitives, a framework more like category learning (or even the construal processes of discourse analysis) is needed. Although they may contribute somewhat to choosing the best canonical view of an object, the Gestalt laws and the local depth cues do not differentiate between familiar and unfamiliar objects. Biederman (1985) proposed a specific set of primitive components, or *geons,* by which all familiar noun-class objects (telephone, cat, etc.) are recognized very early in the first glance, both in the world and in its pictures. Because such geons are presumably redundant in defining any noun-class object, the occlusions provided by a cluttered environment would often not preclude identifying an object. Although the research that would test the identity and attributes of the proposed geons has not yet been done (or whether a model that relies on a specific set of components is viable),[16] the proposal is admirably researchable, with wide potential extensions to the set of questions on meaning and resonances (like puns and priming in language) that would be important to the concerns of Section III. In any case, it brings meaningful components shared by world and pictures to the fore, and raises the study of objects and their pictures (and perhaps of scenes as well (see Section III.B)) to a new level of relevance and specificity.

Note that in these experiments objects are recognized very rapidly, and that the set of geons that define an object are a product of familiarity. How early familiarity and meaning enter the visual process remains unclear. Even Hebb asserted that figure–ground formation, discussed in connection with Figure 2A, was primary (although he did not spell out what he meant by this, or why). First extract the edges, then identify the shapes they define. That is certainly one logical process for recognizing objects. But I have long questioned whether figure formation is fundamental (e.g., Hochberg, 1972b, 1974b); Peterson (1994) strongly challenged the credo that figure–ground segregation must precede the effects of object familiarity or *denotivity;* and Cavanagh (1987) pointed out that the features needed to identify some shape are often mutually indistinguishable before the object is recognized.

The analysis into geons, even if they work as described, is just a beginning. As noted earlier, where an object has some usual orientation, inverting its picture while leaving its components intact interferes more with identifying that object than it does with an unfamiliar one (Peterson, 1994; Peterson & Gibson, 1991; Peterson et al., 1991). Inversion drastically reduces the recognizability of pictured faces (e.g., Diamond & Carey, 1986; Hochberg & Galper, 1967; Valentine, 1988),

[16] Substantial research by Biederman and his colleagues has now shown that simple outline drawings of noun-class objects are recognized as fast or faster than photographs containing surface information, and that some parts of the outlines are more informative than others. We do not yet know how well the set of geons proposed fits the facts of object recognition (they will not do for the recognition of faces and other individual objects, as we note below), and whether they are independent enough in combination to serve as analytic components.

and of their expressions (Thompson, 1980), which do not yield to an analysis in terms of geons in any case. There are other things to represent than noun-class objects, other components to the recognition process than geons, other attributes or events to recognize and react to than the presence or identity of some object.

Naming responses and explicit recognition are not the only responses viewers can make to objects (see Cooper & Schachter, 1992), although they are by far the easiest to measure in experimental psychology. Objects have what we may call narrative significance, some of which they may share with their linguistic labels, but they have consequence of their own. To the Gestaltists, viewers perceive sadness, glee, menace, and value in objects as directly as they do color or distance (Koffka, 1935; see Sect. IIIa); whether or not such assertions are plausible about objects quite generally, it certainly seems true of those objects that are living creatures. And surely pictured faces are not just pictured 3-D objects: they carry character (Gombrich, 1972a; Secord & Muthard, 1955), and they therefore carry expected actions, as well (Hochberg & Galper, 1974). For that matter, objects themselves are not merely identifiable geometrical structures: their familiar usage, their ritual and symbolic functions, their mutual relationships with other objects in the real or pictured field of view—all support some narrative structures rather than others.

In a simple hard-nosed physicalist view, such *tertiary* properties must emerge late in the order of cognitive processing.[17] How early in the course of perceptual processing such responses are entrained is not known. In any case, one must certainly expect them to be involved in deciding where to glance in the next 250 ms, in how the viewer integrates and stores these glances, and in how the viewer can manipulate the memories of what was seen. For much of human history, most pictures serve as narratives, not merely as surrogates or labels for some layout of surfaces in space. Fine art has, in times past, typically conveyed overt stories,[18] and carried more esoteric references and social commentary as well. Most pictures, whether in galleries or magazines, do the same. Subject matter figures heavily in what people say they want in pictures when they are polled (see footnote 24). I do not see how one could step from perceptual theories dedicated to explaining pictures as specifiers of surface distance and orientation, which was how I opened this section, or explaining them in terms of Gestalt laws of organization, to what people use pictures for, and to what pictures can tell us about the perceptual process

[17] Simple sensory "ideas," such as 2-D locus, brightness, and color, are traditionally termed *primary;* the presumably derived distal properties that we perceive in the world, like depth, reflectance, object size, and so on, were classed as *secondary;* and those properties that were thought to be cognitively derived from the secondary properties (such as the intent expressed by the temporary disposition of some perceived person's face) were therefore taken as tertiary. Most of what is to be communicated by pictures would fall into this category.

[18] See White & White (1965) for a history of how the French National Academy both regulated these and made France preeminent. Historical, religious, and dramatic narrative have in this century essentially lost their importance for fine art; the biography of the artist, and the story and philosophy of what it is to make a picture, have since provided much of the discussable content; cf. Danto, 1986.

(as distinct from explicating the static depth cues). Even if geons should turn out not to work, they are at least a serious step toward an object-oriented theory of picture perception.

Such object-oriented approaches should be able to tackle many questions related to the visual arts far more readily than did the older metatheories, but they are even more closely tied to questions of representation. Representation is what perception as a discipline remains most prepared to discuss. The fact is, however, that most people who are now most interested in art are no longer particularly concerned with the representational function per se (although that was certainly not true when much of the most valued painting was done: see Alpers, 1983).

The two major perceptual yet *non*representational functions that the arts can serve are the main concerns of Section III.

III. NONREPRESENTATIONAL FUNCTIONS OF ARTISTIC PRESENTATIONS: EXPRESSIVE, AESTHETIC, AND ARCHITECTURAL

The expressive and aesthetic functions are far more prominent in writings on art than are questions of the fidelity of representation. The problem in discussing them is that although one can bring agreed-upon and usually measurable criteria to a discussion of representation, that necessary feature of any science vanishes as we proceed further into the nonrepresentational functions of art. To exacerbate the problem, although many different writers offer assertions (and often battle cries) about what is true, no systematic agreement now exists, and most value judgments are made according to principles that are deliberately not made public.

But that does not ensure that there is nothing to pursue. The two major functions here clearly exist, and reflect something about how—and why—people look at (and listen to) works of art, even if one cannot say exactly what that is.

Expressive refers to feelings, to emotions, to attitudes, and to the self-expression of the artist; *aesthetic* refers (originally) to beauty, to the pleasure provided, and to whatever factors, including those arising from the other two functions (representational and expressive), engage the disinterested[19] evaluative attention of the audience.

A. Expression and Feeling

In one meaning of the term *expression,* artists portray a person's expressions and postures to communicate that person's feelings or character; the issue is then still one of representing that person. But the represented demeanors of the persons portrayed presumably express their feelings, whereas the proper use of the medium

[19] Disinterested in the sense that no extrinsic or *exogenous* motive (Kruglanski, 1975) is evident as the source of the evaluative attention.

expresses the feelings of the artist in a way the spectator can share. When Rembrandt's self portraits reveal the progressive decline of his body over the years (see Zucker, 1963), it is not Rembrandt the subject of the self-portrait but Rembrandt the painter who expresses this unflinching firmness (Sircello, 1965). In another and less representational meaning, a broad, jagged line may be called on to depict a blunt, harsh person, or used in drawing a threatening scene; a thin tremulous line and an unbalanced, tense composition may be used to express anxiety about some event or scene. And the way the artist's medium is used may itself be expressive without representing anything at all, as when one says that music *is* joyous, not that the music is about a joyous event (cf. Beardsley, 1958, 1965; Zink, 1960). In still another and most important sense of the word, expression is what the artist may express himself or herself, trying by choice of subject matter and style to attain a unique identity, one that may carry connotative meaning as well (e.g., being whimsical, excited, or brooding). Most artists use the elements of the medium not only as signatures (i.e., to identify themselves), but also as signals of their characteristic attitudes toward their subject matter as well (and to some degree, as constraints upon their subject matter). There is little research to support such statements and, as I argue later, little reason to undertake such research.

There are innumerable writings to the effect that color and composition in the visual arts (Ball, 1965; Kepes, 1944; Poore, 1903; Taylor, 1964); melodic structure, scale, and rhythm in music (Gutheil, 1948; Meyer, 1956); words and sounds in poetry and prose (Belknap, 1934; Pope, 1949; Wilson, 1931); and movements in dance (Davis, 1972; Kreitler & Kreitler, 1972; Sorell, 1966) are all endowed with expressive meaning. There is also a large but scattered body of experiments to this point, usually designed to show that expressive, or *physiognomic* judgments (Koffka, 1935) can be obtained from subjects who are shown such elements in a research rather than artistic context (Werner, 1948). Reviews of early research of this kind can be found in Hammond (1933) and in Chandler and Barnhart (1938); a large body of later research is referenced in Pickford (1972).

Such analyses are critical in all applied art, but especially so in advertising (and propaganda), where the connotation of words, of visual elements, of layout composition, of mood music, and so on, must relate appropriately and contribute as desired to the audience's image of the product or the person being represented. Relevant research (including what has reputedly been performed in-house and kept as trade secrets) is carefully weighed (albeit with a validity that is essentially untested in any publicly assessible way). If the psychology of expressive art languishes today, it is not for want of belief in its potential economic payoff.

What is missing is a well-developed and testable psychological theory in terms of which such research can be ordered and which it might inform. The Gestaltists, many of whom argued that at least some of these properties are as intrinsic to our experiences of objects as is their color, never offered a principled theory (for most recent discussion, see Epstein & Hatfield, 1994). The classical empiricist approach (e.g., associations shared because of elements in common, the prosodic aspects of the language that are associated with different classes of message, and the abstraction of a form or category to deal with experience) appears in a wide range of proposals like those of Osgood (1976) and Langer (1958). The empathy theory, as in Lipps's attempt to explain both aesthetics and the geometrical illusions (Lipps, 1900) in terms of an emotional or reactive response that is supposedly even made to relatively simple stimuli, is represented more or less directly by Gombrich (1972a) in his hypotheses about portrait perception, by Schillinger (1948) on music and (via identification with what he termed *modal-vectorial bodily functions and rates*) by Gardner (1973). Words, shapes, colors, and feelings may all share a single "isomorphic internal response"—as held by several Gestalt theorists (see Arnheim, 1954; Koffka, 1935), and in a complex way, by Smets (1973). Smets speculated that an aesthetic stimulus elicits those emotional and synesthetic connotations that also evoke the same degree of arousal (where "arousal" would be measured by desynchronization of alpha-wave activity), and reported such equivalences with colors, shapes, and connotative descriptions.[20]

Although writings on art often analyze some work in terms of the effects putatively aroused by its component elements, I know of no theory that provides combining rules. Without such combining rules, discussions about the expressive effects of the components are neither theoretically nor practically useful. We do not know whether or how the effect of a work of art reflects the effects of its parts as measured separately.[21] It seems clear enough that expressiveness can indeed be attributed to larger parts, or even whole works (especially those, like music and dancing, that are the normal means of celebrating such feelings), but very little research has been directed to this point. Subjects will refer to the emotional impact of abstract pictures and mood responses are made with some reliability to musical selections (Berger, 1970). Pickford (1972) and Child (1969) have done general reviews, and Berlyne and Oglivie (1974) and Pickford (1955) have done factor-analytic studies of subjects' responses to works of art. In such research, however, the subject must make some analytic response, as in words or rating scales, and one must question whether these can adequately represent the effect of an artistic presentation (cf. Gardner, 1973), especially with naive subjects.

For this reason, methods in which subjects reliably perform more objective tasks that are designed to reveal their sensitivity to nonrepresentational qualities of the art seem more valid. For example, subjects will reliably match titles (not necessarily those given by the artist) with abstract paintings; will correctly assign tops and bottoms to them (Lindauer, 1970); and are able to match paintings by Klee with

[20] More physiological arousal had previously been found in response to red than to blue (Wilson, 1966), and Smets (1973) reported that subjects matched colors, shapes, and verbal expressive concepts to each other in the same way that their arousal patterns were related (using the duration of desynchronization of alpha waves as the measure of arousal). What alpha-wave desynchronization tells here is of course another question.

[21] That is, of course, the problem which sank Structuralism (meaning the psychological school: Hochberg, 1972a).

the music that presumably inspired them (Minnigerode, Cianco, & Sbarboro, 1976; Peretti, 1972; Wechner, 1966). The method of work-to-work comparison has been used to measure the ability to judge whether works of art are by the same artist, using literary selections (Westland, 1968), musical selections (Gardner, 1972a), and paintings (Smets & Knops, 1976). Such procedures might avoid some of the problems inherent in standard tests of aesthetic judgment (Child, 1969) and provide an effective research tool for the measurement of artists and periods, as well.

Similar procedures might be applied to artistic style, which may be the most important expressive aspect of art.[22] The artist's choice of contents may itself amount only to another aspect of style (Sontag, 1961). Style (what is usually meant by "expressing one's personality," by those who use the phrase), has been an ever-increasing component of the art market and therefore of aesthetic development (cf. Grosser, 1971) since the Renaissance. Without a distinctive and memorable style, no pure artist (and few applied artists, like cartoonists, singers, or dress designers) can have a viable career. If that is true, and I think it is, one cannot really feel that one understands the perception of pictorial art until this aspect of expression is understood. The discussion in Section III.C may be relevant to this point.

Another and much more elusive way to characterize pictures, which is neither a matter of representational adequacy nor really one of expression (as it has been discussed in this section) is traditionally the concern of experimental aesthetics, which is considered next.

B. Art as Pleasurable or Engaging: Experimental Aesthetics and Preference

Experimental aesthetics was founded by Fechner (1876). The central thread is psychophysical: an attempt to predict the aesthetic value of stimuli from their identifiable properties. (Fechner also, of course, founded psychophysics.) Woodworth (1938) presented an admirable discussion of the field to his time; for early bibliographies, see Hammond (1933) and Chandler and Barnhart (1938). Reviews or collections of papers are found in Berlyne (1971, 1972, 1973, 1974), Child (1969), and Pickford (1972). Many of the papers include efforts to relate some aesthetic prescriptions to abstract mathematical formulae, to neurological speculations, or to some variety of stimulus–response motivation theory. Most do not take the aesthetic value of real art (e.g., museum paintings) as their subject; two recent attempts that do (Batovrin, 1993; Stephan, 1990), to which I return briefly in Section III.C, do not attempt to predict measurable hierarchies.

22 For eloquent defense of this point, see for example, Tolstoy, 1899; Croce, 1915; Collingwood, 1938. There are also some to whom the major function of art education is to teach children to express themselves (Read, 1943; Gardner, 1973). From that viewpoint, the fact that the clearly recognizable individuality of children's drawings declines as they mature is offered as evidence that a decline in artistic ability has occurred, but of course that judgment rests on which definition of artistic function is emphasized.

ent, 1963), which must surely interact with the subject's familiarity with the canons of culture. Second, the stimuli used are, by and large, random shapes of a sort that no reasonable person would spend a glance on outside of the experiment, and are surely not worth either arousal or preference.[23] What arousal and preference there are must, it seems to me, derive from the challenge of grasping the principles that should guide the choices. I will return to this point after sampling the research area.

Some steps have been taken to move experimental research on art to more meaningful pictures (cf. Lindauer, 1970; Wallach, 1959). As I noted, some factor analyses of similarity judgments or rating scales of various selections of real artworks have been reviewed by Berlyne and Ogilvie (1974) and Pickford (1972). Analytic, evaluative and educational writings about art deal almost exclusively with the artworks in museums and equivalent collections. To the cognoscenti, this provides a large but finite common culture to discuss, to study and to assess. To the perceptual psychologist who seeks generalizable data about visual aesthetics, it should be important to know whether museum and non-museum pictures differ intrinsically in how they affect most average viewers. In 1990 and 1991, Lindauer reported a pair of studies which found virtually no differences in subjects' preferences for (and judgments about) museum art and mass-produced art. Most recently, two Russian artists, Komar and Melamid (1993) commissioned a survey questionnaire on American public attitudes toward various aspects of art, including color, subject matter, style, and so on, which served as a guide for a painting tailored to that taste;[24] this event may arouse some interest among art historians and philosophers, but experimental psychologists cannot take the interviewee's data at face value. Regardless of how reliable or valid data on aesthetic responses (preference, looking time, etc.) may be, they are not informative to perceptual theory unless they allow some kind of stimulus measurement (whether through instruments or through judges) and some degree of generalization.

The bulk of the experimental research remains the work on color preference (summarized in Pickford, 1972), and on how the complexity or typicality of visual and auditory nonsense patterns affects subjects' interest in them and affects the subjects' judgments of preference or pleasingness (a great deal of the work with adults is summarized in Berlyne, 1974, some work with children is summarized in Gardner, 1973, and Pickford, 1972, and work with differential habituation of

[23] To most object-oriented perceptual theories (at least since Hebb), which make some degree of meaning and familiarity part of the earliest visual processing, arbitrary patterns of dots are complex, rather than simple, and findings based on nonsense patterns need to be validated with principled selections of more familiar and meaningful pictures.

[24] This tabulation revealed (among other things) that respondents expressed strong color preferences; that design factors are clearly important in shopping quite generally; that traditional style and landscapes are preferred in pictures; and that more diversity in taste is shown by those claiming greater experience with art. The survey is itself part of an artistic statement, and the questions it raises are more important than the answers it provides, which may nevertheless be useful to the companies that sell the framed pictures one occasionally see for sale in the lobby of the supermarket, and perhaps to advertisers. (In research on advertising, lists of what will attract readers' attention in a picture have long been compiled, based on direct or indirect measures of where they look in a target magazine.)

I raise some of Woodworth's points, add a few, and then discuss why this field might concern perception psychologists. First, I feel that most research in experimental aesthetics really has nothing to do with the perception of beauty or the arousal of an aesthetic experience, and that subjects' preference judgments cannot support any simple interpretation. *For those very reasons,* however, I believe that research in this area is applicable to the appreciation of art (particularly, pure art). Although the criticisms raised in this regard are probably valid, this research area should remain of modest interest both for art and for psychology.

Woodworth pointed out that in experimental aesthetics the object of study is the response to the beautiful, the sublime, the tragic, the comic, or the pathetic. The response should depend on the subject's feeling rather than on intellectual perceptions or judgments. In the laboratory, however, the subject must surely take the questions to mean not How much feeling is aroused in you? but Is this object pleasing or displeasing? In this way the results belong under the heading of judgment or taste rather than feeling. Most research involved having the subject make rankings or choices according to preference, and Woodworth noted that the very fact that nearly everyone was able to select a most pleasing rectangle when Fechner solicited such judgments (in the process of testing claims that had been made about the "golden section," to which we return in a moment) was itself an important psychological result: "A mere rectangle, we might suppose, could have no esthetic effect one way or the other" (Woodworth, 1938, p. 385).

To these comments, I add that psychologists have known for decades that introspection will not serve to reveal directly the inner workings of our minds. The Helmholtzean view, which still was adherents (Gregory, 1993; Rock, 1993), that perception proceeds by *unconsciously* fitting the most probable explanation to the information we receive, should, as in the James-Lange theory of emotions and the attribution theory of social psychology (cf. Bem, 1967; Nisbett & Wilson, 1977; Schachter & Singer, 1962) apply as well to judgments about feelings and attitudes. Even if subjects could consciously observe their preferences, in general they usually seem to do more of what the situation demands than what they are ostensibly asked to do (Orne, 1962).

One might think that the last point can be disregarded because the stimuli used in laboratory studies of experimental aesthetics have often been random polygons or other relatively neutral patterns, with no inherent meanings to contaminate the findings. I do not believe, however, that the aesthetic-preference *task* can be a neutral one: It asks subjects to expose their tastes and their sensibilities, to make themselves vulnerable with regard to a dimension of preference having the strongest of social and intellectual connotations. (In fact, preference tests have also been used as personality tests: cf. Barron & Welsh, 1952.)

Furthermore, nonsense patterns may not be what they seem. First, they are not alone in the subject's field of judgment, because any set of stimuli implies the entire class of stimuli from which they can be inferred to have been generated. This is true of subjects' judgments of the patterns' "goodness" (Garner, 1966; Garner & Cleminfants' looking at various kinds of stimuli is summarized in Cohen, 1976, and Olsen, 1976). Given that looking behavior is elective, what keeps viewers looking when no exogenous task requires it should surely be of interest to perceptual psychologists (practical considerations aside, which are not financially trivial). And given that exogenous motives are so numerous, sociologically conditioned, and diverse, progress here would seem to require the identification of some few core endogenous determinants. As Blich (1991) noted, there is a burden of allegedly central concepts in aesthetics too cumbersome to handle, and very few empirical tests. Continuing the theme raised at several points in this chapter (and in its 1978 version), I add that this burden is so cumbersome largely because of different artists' and writers' different agendas, competitive market for selling and investing in valuable pictures, and (absent an authoritative Academy) a lack of agreement on artistic value and how to measure it.

What I have therefore selected from the rich but tangled literature on experimental theoretical aesthetics reflects a path that I feel may be worth pursuing. Except for the Smets (1973) study, the color work does not seem to be of theoretical interest. Works on the effects of complexity and typicality may be of interest, because the theoretical statements hint at ways to incorporate other proposed aesthetic principles and allow connections with each other and with more general theories of visual perception and cognition.

Perhaps the three most famous aesthetic principles for achieving beauty in visual art are these: The *golden section* (that is, supposedly the most pleasing of proportions), which since antiquity was claimed to be the proportion in which the whole is to the larger part as the larger is to the smaller: $1/x = x/1 - x$, or $x = .618$ (in a rectangle, that would require one side to be .618 times the length of the other); Hogarth's *Line of Beauty* (an ogive, or S-curve), used as the main line of myriad works of painting, sculpture, ornamentation, and pottery; and *Polykleitos's Canon,* the Doryphoros, a statue providing a model and set of rules that seem a watershed in Greek statuary. Of these three, the first has been subject to the most research (reviewed by Woodworth, 1938, and Valentine, 1962). Rectangles with that proportion are, by and large, the central tendency of preference judgments. Why?

Witmer (1894) ascribed its preferred status to a pleasing unity of diverse parts; Weber (1931) proposed (in the *Journal of Applied Psychology,* we should note, where a fair amount of such work was published) that any figure sets its viewer the problem of seeing it as a unit and, if it is too easy to do so, interest is quickly lost, whereas too much difficulty spoils the aesthetic effect. These formulations reflect an age-old and developed theme: Beauty or pleasingness is some function of complexity and/or other factors that affect the ease with which the viewer can see it as a unit. The formulation sounds plausible (although we should also note that most recently, Boselie, 1992, found that subjects showed no special preferences for the golden section.) How might we extend it to other measurable stimuli, and what function will predict subjects' preference judgments (i.e., the so-called hedonic tone of the stimuli) from stimulus measures of the objects they are judging?

Birkhoff (1933) proposed that, within any class of objects, the aesthetic value is M

= O/C, where O is some measure of order and C is a measure of complexity. The means obtained from subjects' preferences for polygons he had constructed gave the same order as did his measure of M. There have been several failures to corroborate this model (Davis, 1936; Eysenck, 1968; Eysenck & Castle, 1970). Other quantitative models have been proposed. Adding a "pleasure center" to his nerve-net model for the detection of lines and angles, Rashevsky (1940) provided a good fit to Davis's data. A remarkable effort to provide the mathematical basis for manufacturing music according to his own theoretical formulation was published by Schillinger in 1948—with what effect, I do not know. Information-theory versions of Birkhoff's formula (Moles, 1966) take their somewhat less simplistic accounts of order from *subjective* predictability, or redundance, which should vary with learning and motivation (cf. Moles, 1966; Smets, 1973, measured subjective redundancy in her research by adapting a version of Attneave's guessing technique). Eysenck proposed an inverted-U-shaped function relating preference and complexity (Eysenck, 1968; Eysenck & Castle, 1970). So did Berlyne (1967), on the grounds that arousal (activation of a cortical reward system) increases linearly with complexity, whereas hedonic tone is greatest at an intermediate level of arousal (Hebb, 1955; Lindsley, 1957).

In Berlyne's proposal, the arousal potential of a stimulus pattern depends on several factors, including the pattern's intensity, its association with significant events, and its *collative properties.* These last are formal characteristics such as the pattern's variation along dimensions like familiar-novel, simple-complex, expected-surprising, and so forth. Arousal presumably increases with complexity (among other things), and hedonic tone is greatest at intermediate arousal levels, so hedonic tone should be an inverted-U function of complexity. Judgments of interest versus disinterest, however, and of complexity versus simplicity (and other verbal measures of arousal) should increase with the complexity of the stimulus (often measured in informational terms or uncertainty).

In many cases (Crozier, 1974; Dorfman & McKenna, 1966; Normore, 1974; Vitz, 1966; Walker, 1973; Wolhwill, 1968), the expected relationship between hedonic tone and complexity is found; in others, pleasantness or preference ratings increase monotonically with complexity (Hare, 1974a; Jones, 1964; Reich & Moody, 1970; Vitz, 1964). Reich and Moody (1970) even found pleasantness to decline with complexity, as in Birkhoff's proposal, when they used stimuli to which subjects had been habituated. As Smets (1973) pointed out, however, and demonstrated (using two-element matrix patterns that varied in redundancy as well as in number of elements; cf. also Snodgrass, 1971), given a nonmonotonic function, the part of the curve that one obtains depends on the range tested. The effective order, structure, or redundancy that a subject can discern should depend on the stimulus pattern's familiarity (cf. Goldstein, 1961; Harrison & Zajonc, 1970) and perhaps on the subject's artistic training (Hare, 1974b; Smets, 1973). It seems likely therefore that pleasingness and preference judgments are *not* a monotonic function of complexity in such experiments. And we should remember that where they are, that fact may reflect how viewers handle the preference task when confronting meaningless or nonsense shapes[25] (see pp. 181).

Alternative models can be fitted to these facts. In the McClelland, Atkinson, Clark, and Lowell (1953) "butterfly curve" proposal, a stimulus to which we have become habituated is neither pleasing nor displeasing. As it departs from this adaptation level (Helson, 1964), the stimulus passes through a maximum of pleasingness and finally becomes unpleasant and noxious. An application to stimulus complexity is reasonably straightforward (Terwilliger, 1963) and could serve as a testable amendment to theories that assign beauty or attractiveness to the average or to the prototypical (e.g., in faces; see Langlois & Roggman, 1990; Perett, May, & Yoshikawa, 1994, to support some such formulation; as to the need for amendment, see Alley & Cunningham, 1991; Hochberg, 1978. Recent results reviewed by Blich (1991), however, do not show reliable relationships between judged typicality and judged preference, but that may merely reflect problems with conscious judgments about typicality and perhaps the stimuli used.

In any case, something like the expected curves of preference and distance from norm has been found in some laboratory experiments (Day, 1967; Haber, 1958; Munsinger & Kessen, 1964), and the cycle of unpopularity, popularity, and neutrality through which popular songs and other fashions swing grant it considerable anecdotal plausibility (see also Wohlwill, 1966). We would expect therefore that small departures from some culturally familiar schema help motivate perceptual inquiry. Both the golden section (Fischer, 1969; Lalo, 1908) and Polykleitos's canon (Ruesch, 1977) have been claimed as cultural rather than mathematical norms. In fact, Ruesch argued that Polykleitos's canon embodies the central tendencies of actual early anthropometric measurements from which, once established, subsequent sculptors departed for specific effects. The higher attractiveness of photographically or digitally averaged faces, mentioned above, may reflect the same relationship.

A plausible parallel can thus be drawn between some laboratory findings, and at least some features of the less simplistic world of art. Missing from discussions of both, as I see it, is the question of motivation. In the tasks set by the traditional methods of experimental aesthetics, the subject agrees to judge the relative merits of some members of a stimulus set. That challenge, and not the inherent beauty or interest of the stimuli, must be what maintains the subject's interest. The more complex the stimulus, the more there is for the subject to consider before answering, and the more to sample, integrate, and store. It is not surprising, therefore, that looking and listening time increases with the complexity of the stimulus patterns, as in fact it does (Berlyne, 1974; Crozier, 1974; Faw & Nunnally, 1967; Hochberg & Brooks, 1962b, 1978), and as subjects' ratings of *interestingness* do, as well (reviewed by Berlyne, 1972). The latter ratings, in fact, increase *monotonically* with complex-

25 As Normore's subjects asked spontaneously in one experiment, "How can a dot be beautiful?" (1974, p. 113)

ity, reflecting, I suggest, the subjects' continued search to find some order or principle in the pattern that will account for the occurrence and placement of most (or at least some) of the elements.

What about the hedonic tone associated with such schema-testing activities? Weber's explanation (p. 183) will do nicely: If a pattern is so simple that it offers no principle to generate and test, or if it is so complex that (given the subject's background and motivation) no discernible schema makes the pattern "right," it is not pleasing, because no perceptual achievement has rewarded the subject's efforts. Note that this makes the grasping and testing of the schema, not the complexity or the arousal per se, the basis of the hedonic tone, and that *a motive to undertake the task is needed: the hedonic tone is not inherent in the stimuli.*

There is much that such a schema-testing account must leave out, especially about aesthetic response to real pictures viewed as art objects.[26] The inexpressible feelings that sometimes arise, for which terms like *beauty, pleasure,* or *preference* seem inappropriate, are not addressed by schemas and their like. Words do not do well either in discussing visual aesthetics, but critics and philosophers of art try to meet the challenge. One strategy is to discuss how the picture affects unconscious, nonverbal, or preconscious levels. Because the affects are not consciously available to the writer or the viewer, some fairly detailed theory is needed about the workings of the unconscious. Variants of psychoanalytic discourse with its repertory of symbolic meanings, related sets of assumptions about the viewer's unconscious childhood memories, and analyses of metaphors (as inherent in the visual means of representation, not as provided by the "text" being represented; cf. Wollheim, 1987, pp. 308–315)—all of these have been used, with good or bad effect, to illuminate or elucidate museum art. Such analyses often start with what the viewer has already perceived explicitly, but point to other relationships entailed in composition, coloring, style, and so on.

In a related vein, Stephan (1990) granted the right hemisphere of the brain a fully developed world of visual associations not available to the linguistic left hemisphere (although recent studies by Biederman & Cooper, 1991, did not find the widely touted hemispheric superiority in recognizing drawn objects on which

[26] For example, Christine and Fred Attneave's verbal response to an earlier (spoken) version of this proposal was: "What about the pleasure of first seeing an intensely blue lake?" I think that such questions can be handled, but this is not the place to try to do so. Another troublesome problem concerns how much a member of the audience expects to fit into a given schema. Some amount of any artwork (particularly one in which the elements are presented over time under the artist's control, like music, dance, literature, or motion pictures) is *texture,* and is needed merely for verisimilitude or for filling. Some of the artwork will have *outcome* and be important to the final structure. In assessing how economical a work of art is, we probably should be attending not to the total complexity, but to that portion that the viewer or listener takes as part of the structure (i.e., the viewer's *subjective outcome structure*). In painting and in drawing, one does not take all of the brush strokes and the cross-hatches as significant elements, yet some of them, in each case, do serve special functions in the artist's design.

this theory rests); perhaps such clouds of partially aroused sensory associations (cf. Titchener's context theory of meaning) could be studied through the priming effects of geons, or other early visual-object components. Similar in some respects is Batovrin's (1993) concern with how art communicates significations which, in Kandinsky's words, are feelings for which we have no words;[27] in Batovrin's system, these arise from the detection of fractal order, not identified consciously, that is normally undetected in the chaos of cognitively unprocessed sensory data.

Although these various and ineffable responses are attributed to the visual stimulus offered by the work of art being discussed, it is not clear how they might be translated into perceptual research. That does not necessarily make them wrong, but it does at present leave them beyond experimental study. In any case, these examples are only a tiny sample of the many different criteria by which philosophers, critics, and artists judge works of art to be of greater or less artistic (or aesthetic) value. That means, I believe, that there are many things we mean by art: in fact, whatever can engage an appreciative and informed following. (It seems significant that the dealer who was "ahead of all others" in recognizing the merits of Cubism when no one else thought it of value, and was instrumental in its immense success in overcoming early opposition, could not tell what was good or bad in other later styles [Assouline, 1990]). And this brings us back to the schema-testing theme. In sophisticated art, an audience needs to be educated in what can be taken as the artist's premises and purposes, and in the tradition against which the artist makes his "statement." Without that education, or without the intention to perceive how the attributes of the picture fit each other and fit the schema provided by the tradition to which the work inescapably refers, there is nothing for the viewer to achieve. If one knows nothing about such art, there is then no way to know what one likes. For that matter, there may then be nothing to get the viewer engaged in the first place.

Although there may be many attributes of pictorial art that a schema-testing approach does not address, therefore, I can reclaim it for the educated aesthetic appreciation of even those works whose individual aesthetic value rests primarily on such evasive attributes. This is so because mobilizing and testing schemas is, in this approach, the process by which visual information is carried past the momentary sample provided by the individual glance. And that process is especially important where (as in much Abstract Expressionist art) there is no economical verbal narrative that can serve.

By this argument, much that is in fact not representational in nature or intent draws on the same cognitive processes by which we apprehend the structure of representational pictures. And that does not stop with pictures, as the last section attempts to show.

[27] Cited in Batovrin, 1993, p. 42.

C. Beyond Pictures: Grasping the Form and Order of Architectural and Environmental Structures (and of Nonspatial Logical Problems)

If pictures work because in some respects they are not that different from the world, then in those same respects the world is not that different from pictures. In Sections I and II, I argued this with respect to pictured and real objects, proposing that they share the same schematic maps. I think the same point can be applied to the setting of those objects, that is, to the structures of those surfaces and edges that lie beyond what one can quickly reach. Objects further than a few meters offer no useful accommodation, convergence, or binocular disparity; nor do moderate depth differences then offer useful parallax with head *rotations* (see Cutting & Vishton, 1995; Hochberg, 1980).

Of course, if the viewer moves laterally while keeping his or her gaze fixed on the edge between a nearer and farther building, or keeps that gaze fixed during a turn of the head so that foveal vision then receives the parallax to which the visual system is highly sensitive, potentially usable depth information then becomes available. As discussed in Section II.C, the invariants in the optical transformation that the viewer receives while moving in space offer information about surfaces and layouts that Gibson had proposed (1966, 1979) would provide for direct and veridical perception of the surfaces, layouts and the movements themselves. Architectural theorists have not missed this point (cf. Benedikt, 1979). Nonetheless, when the viewer's movements are small, the static depth cues may overcome the information theoretically available within the optic flow and once a depth arrangement is misconstrued, instead of being used as depth information the parallax can also be misconstrued as illusory concomitant motion (see p. 236n).

The static monocular (pictorial) cues are therefore mostly what moderately distant architectures and landscapes, in the real world, initially offer the moderately inactive observer. And because the potential field is much wider than in most picture viewing, and extends beyond the limits of peripheral vision, the task of integrating information from successive glances at different parts of the environment must span not only the time from one saccade to the next, but also the much longer times that head and body movements take.

Visual exploration under these wide-field conditions is even more elective than in pictures. When some part of the environment lies beyond peripheral vision, it can offer no invitation to look at it; neither can it offer any expectations (cues) about where desired information can be found, or offer a degraded view of what had been disclosed by previous glances. Structural schemas must be even more important in the perception of architecture (Hochberg, 1983) and of wide-field environments quite generally, and to the perception of their order and their aesthetics.

We use the term *object* for whatever maintains a relatively fixed structural relationship between its parts, despite eye movements or changes in the observer's viewpoint. The environmental or architectural objects considered here are large enough to exceed peripheral vision from a single standpoint: a large building, a complex, a piazza, a scenic landscape. The relevant architectural or environmental object schemas must (at least) act as maps of such structures if they are to guide observer's viewpoint changes, and to store the information then available. Within each glance, we would expect the structural cues (the Gestalt organizational factors and the local depth cues) to apply much as they do in pictures, providing expectations about which side of an edge is the occluding surface and what features are part of the same object. But the scale of the objects relative to the momentary visual field must have consequences.

One consequence is that the large-scale object's structure is more likely to be misconstrued. Given that the objects in question may extend beyond each glance, the "assumption" of good continuation must be particularly important, but is probably subject to error wherever roughly parallel contours of similar contrast (arising from surfaces' edges, occlusions, or corners) fall within successive glances. We have seen that an insensitivity to structural contradictions between local depth cues can be demonstrated even within a single glance (Fig. 2D). Misconstruals of architectural arrangements are probably quite likely, if good continuation is indeed more vulnerable to mistakes and given the greater distances between the local depth cues. (I will not here consider the argument that evolution surely must have assured our ability to perceive environments correctly, which I would be glad to debate in some other setting; cf. footnote 28).

Not all architects wish to avoid illusion (e.g., Eisenman & Gehry, 1991). It seems likely that those who are concerned with having a distinct and identifiable large-scale structure (i.e., one seen as the correct arrangement of surfaces and volumes in 3-D space) must work to avoid such misconstruals: correct construals are not automatic. (Of course, the viewer can usually work out the correct structure with some effort, but that would require first noticing the inconsistency, and then striving to reconstrue the view correctly. Escher's pictures of impossible buildings are suggestions of how much work a much larger structure might require.)

As a second consequence, the viewer may not be able to grasp readily, or to keep in mind, how the different views fit together. To perceive a large construction's overall form (or a region of a landscape or of a city) normally requires at least several glances. Because these successive views may be achieved through quite different behaviors (saccades, head turns, body turns, etc.), it seems unlikely that their information is integrated simply by placing them within a spatial framework or coordinate system. Unless the structure viewed is already a familiar one, which can be identified by some single feature and can summon up an object-centered map, reference points or landmarks are probably used in stitching the glances together. By landmark, I mean some feature or region that is recognizable to peripheral vision in all the glances in which it falls (Hochberg & Gellman, 1977; Lynch, 1960). Other locational indicators may be relative automatic ones (like the slant of sunlight, or the diagonals caused by convergent perspective; but see below), and the viewer can with effort parse the view by careful attention to the extraretinal signals. Although I know of no experimental research here, I can remember situations in which even time and effort were insufficient.[28]

Landmarks and regional recognizability should therefore be important in recognizing the overall form of such large-scale objects. A distinctive tower (Lynch, 1960), or perhaps any large nonrepeating asymmetry (Hochberg & Gellman, 1977), will do as landmarks. Biederman (1987), citing a dissertation by Mezanotte (1981), suggested that *types* of scene (equivalent, I think, to the class-noun objects to which his recognition-by-component proposal is addressed; see p. 175) are recognized very rapidly in terms of clusters of geons (see p. 175), which preserve the aspect ratio and relations of the largest visible geon within each object. If true, this should be important in constructing and evaluating recognizable architectural regions of environments, like neighborhoods.

But location with respect to a landmark or region is not of itself enough to make the form memorable from glance to glance, or from one point to another while walking through the structure or neighborhood. The use of simple Platonic forms (circle, square, etc.) and forms with what we would now term *nonaccidental properties* (Section II) are often stressed as important to architectural aesthetics (Prak, 1968): having well-defined familiar relationships between their parts perhaps informs the viewer where the other parts can be found. Indeed, the visual design of buildings and complexes is usually intended to offer a recognizable form (O'Neill, 1991) that itself serves multiple goals: to communicate the constructions' overall and more local functions, to be individually recognizable, to provide an ambience of time and place, to be interesting, and so on.

With so many goals that the visual form of environmental structures might fulfill, and with many choices probably to be made between them, there is clear occasion for evaluation and aesthetic judgment. Because there now seems to be no agreement about what the aesthetic goals of architecture should be (Shepheard, 1994), the perception psychologist can make a contribution at the center of the enterprise. Some of the less artistic and more popular bases for aesthetic judgments depend only trivially on what perception can offer (e.g., the pomp, the nostalgia, the evocation of earlier or different lives; on the bridge at Concord, or in Rue Danton, it is surely historical imagination and not the architectural form that invites my contemplation; much would be missing from an identical stimulus, an exact replica, in some theme park). Some aesthetic judgments may depend on factors that are clearly perceptual and that can be addressed by perceptual research

[28] Successive glances at a gigantic Jackson Pollock canvas, attempting to decipher a maze, or attempting to detect the inversion in Figure 1 should provide convincing demonstrations, outside the laboratory, that neither extraretinal signals, nor visual invariances under transformation, are enough for easy integration of views without memorable form or landmarks. These are all artificial ("unecological"), but the existence and nature of protective coloration in animals testifies to the general fallibility of the principles on which all visual systems rely (see Hochberg, 1978; Metzger, 1953).

tools (like studies of what makes architectural spaces seem more open or more closed; e.g., Gärling, 1969; Hayward & Franklin, 1974) but that hold no clear importance for current perceptual theory. Some questions of architectural or environmental aesthetics would probably interest both disciplines (e.g., does the smooth linear perspective provided by buildings of equal height, as in many Paris streets, provide vistas of greater perceived depth than the same underlying and invariant but jagged perspective provided by unequal heights, as in most New York streets). Some questions which can probably be raised and answered most naturally in the context of architectural and environmental structure are fundamental to an understanding of visual cognition quite generally.

One such question is that of *affordances* (Gibson, 1979) or *means-end readiness* (Tolman, 1948): the behaviors that some disposition of surfaces will support. Köhler's ape, Sultan, showed that affordances are not automatically invoked by the environment, but it still seems true that something important about the schemas that guide actions must rely on the parameters of environmental structure. Research on how the perception of stairs and doorways relates to their potential ease of use (Warren, 1984; Warren & Wang, 1987) shows that it is possible to give the concepts of affordances in particular and schemas in general more specific content.

A much larger and fundamental question that comes to the fore in the perception of large-scale structures is that of the schematic map, versions of which I held were essential in looking at pictures (Section II) and important in aesthetics (Section III.B). In comprehending architecture and urban environments quite generally, the need for such a concept becomes unavoidable. As long as one talks about stimulus information, which one can do readily with respect to representational pictures and somewhat less readily with nonrepresentational art, the guiding schemas, which are unobservable and difficult to specify and study, can simply be ignored. But those not well schooled in a particular architectural construction or city neighborhood must not only stitch their glances together in order to grasp the form of the structure, but must be able to consult that form, and derive answers from it to guide their behaviors when the overall view is no longer available. Prosthetic devices can help: With map in hand or in mind, the wanderer can traverse an unfamiliar building or a landmarkless neighborhood as though its overall structure were clearly in view and fully grasped.

How well an architectural form is grasped is both practically and aesthetically significant, but it is of cognitive importance as well. Maps and diagrams may guide behaviors in mechanical ways that make it unnecessary to grasp the overall form, but maps and diagrams themselves may be more or less difficult to grasp and to remember (cf. Tufte, 1990). A remembered map substitutes for the schema that the viewer must form to integrate and store successive glances; studying what makes such aids most useful for that purpose should tell much about schemas and their characteristics. For there is no reason to believe that the schematic maps that are used in exploring and regenerating perceived architectural form are utterly different from those used in sampling and storing a picture's representational content;

from those used in discerning the cultural context of that painting (or of any other art object); or those that have proved to be helpful in grasping the meaning of data (Wickens, Merwin, & Lin, 1994) or in reasoning one's way through a difficult problem in logic (Bauer & Johnson-Laird, 1993) and may be used, less formally, in reasoning quite generally. Perhaps the architectural and environmental schema may require more assistance, and be open to such assistance, just because of the scale of time and space over which they must be consulted.

Architecture is obviously not merely a perceptual problem. A building or a piazza or a neighborhood each has its own set of severe economic, mechanical, and historical constraints, and its functions are not normally limited to visually pleasing or impressing the viewer. And the stakes are clearly different, with the architectural structures being more of a salient "statement" by the owners than are paintings. And finally, although there are the odd exceptions, architectural constructions rarely represent the other things and people in our environment, and therefore do not raise the immediate epistemologically flavored questions that pictures do. But on reflection, architecture does raise many other of the problems that picture perception does, and offers a different viewpoint from which to consider the solutions to those problems.

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