CHAPTER NINE

Drawing Conclusions

Second, it is crucial to understand how the world can be represented. The world can be shown via displays that transform it and yet in some fashion repeat it. In particular, outline drawings are not copies of line-like shapes found in nature. In some way they are graphic equivalents of features of the world such as boundaries and elongated shapes. The question around which most of this book has circled is, How can people understand the meaning of lines as axes without the help of vision?

Perception of shape involves appreciating the distribution of tangible and visible surfaces--the arrangements of flat and curved surfaces that compose individual objects. Can the blind recognize and reproduce objects in line drawings, much as the sighted do, since they have a ready access via touch to combinations of surfaces? Reaching out from a fixed position in space is governed by the principles of direction that permit visual projection. Can the blind capitalize on their appreciation of directions from a vantage point and apply this intuitive understanding of the role of the observer's location in an ambient world to the devices used in pictorial displays to show the orientation of objects? It is, as Arnheim writes, a far cry from someone successfully pointing to the sides of an extended object in space as the object recedes to someone successfully appreciating a line drawing of the sides of the object in perspective.

Being rational animals, we are suited for the use of reason, Arnheim notes following Kant. Hence transformations of form should often be detected as deliberate, as motivated by a purpose other than just copying the shape of an object. This recognition should provide an avenue for pictorial tropes, metaphoric devices used to communicate without replicating the referent. Touch goes to and from the mind, hence tactile pictures should be suitable vehicles for tropes.

In Arnheim's view, realistic representation is only one among many equally valid styles. Like Arnheim, I have taken the view that it is not my task to teach the blind the pictorial standards of the majority. Rather, I have tried to provide tasks and displays to which the blind can react. Their reactions indicate what they deem to be appropriate within the limits set by the tasks and displays.

Arnheim's discussion of the aims of the study of picture perception and haptics stems from a Gestalt theory of perception, which is somewhat at variance with the positions I have taken here. Notably, he thinks of perception as "dynamic" and regards haptic perception in particular as concerned with the dynamic properties of pushing and pulling. The result must be, he concludes, impressions of effort and relaxation "in a purely abstract, that is, shapeless fashion." I argue instead that the mechanism of haptics is triggered by variations in resistance, but the percept that arises is
one of shape, not just force. According to this theory, the dynamic properties discussed by Arneheim could underlie expressive properties perceived in displays that suggest tension, bending, balance, and shifting weights. Ultimately, a coherent theory of perception will, I think, include these dynamic properties and show how they can be represented in a picture. At the moment, the only approach to dynamic properties here is via expressive stick figures, and there is still much to be done to create an articulate theory of expression and form.

DIDEROT'S CONCLUSIONS

If I were to reach back into history to select an early, clear precursor of the present framework for ideas about form depiction, the list of distinguished contributors eligible for praise would be impressive. The question of the relationship between touch, vision, and form was first brought to prominence by William Molyneux in a letter to John Locke, and vigorous responses to Locke came from Reed, Berkeley, Condillac, Lotz, and Kant. But it was Denis Diderot in the late eighteenth century who put forward the most prescient assessment, in practical terms, of many of the main findings of today.

Diderot wrote that touch excels at giving the blind person the idea of three-dimensional objects. He quoted a blind man to this effect: "When I place my hand between your eyes and an object, you see my hand and not the object, and the same thing happens to me when I look for an object with my stick and find another instead" (Diderot, in Morgan, 1977). The blind, Diderot wrote, readily realize that objects interpose in three dimensions between the observer and the object. Thus, touch has some sense of perspective. "The blind man of Puiseaux," Diderot observed, "judges the nearness of fire by the degree of heat, the fullness of containers by the noise of the decanting liquid, and the nearness of bodies by the action of air on the face." "How does the blind person form ideas of space?" Diderot asked. His answer: by "the movements of his body, the successive existence of his hand in different places, and by the continuous sensations given to him by an object that slides through his fingers." In touch, a taut thread is a straight line and a sagging wire a curve. The blind person has no difficulty combining these sensations or points into shapes. A curve is a surface of a concave or convex solid in touch. The blind can even mentally expand or contract a shape. "By these means," Diderot vouchsafed, "the congenitally blind person can construct points, surfaces and solids; he could even have a conception of a globe as large as the Earth." He even reported that a blind person "with a bit of practice...was able to recognize a friend from a drawing made on his hand." A succession of pencil strokes on the skin constituted a picture.

Diderot's anticipation of results of studies on haptic pictures with the blind not only anticipates the work I have reported here; it also is a precursor of interesting experiments using the skin as a kind of canvas. Studies with pictures taken with a television camera and turned into pictorial arrays of points on the skin, some vibrating and some quiet, have been undertaken for more than two decades (Bach-y-rita, 1972; White, Saunders, Scadden, Bach-y-rita, and Collins, 1970; Epstein, Hughes, Schneider, and Bach-y-rita, 1989). It is difficult to make a patch of skin (which has low acuity) act as a retina (which has high acuity) responding to small images of squares, circles, and triangles of vibrating points. But it is not impossible. Motion seems to make the detection of shape slightly easier. I think that there is more promise for raised haptic pictures to be explored via touch than for images impressed on the skin, judging by the difficulty in attaining significant comprehension of patterns on these "television sensory substitution" devices. But new tactics are being devised for these devices, and there is every reason to hope for a break through.

Diderot did not offer a theory of pictures or a list of the features of an object that would be suitable for outline drawing. He argued that we are endowed with sensations, which we can combine in perception, but he was at times unclear about how sensations could lead to perceptions. He rather vaguely concluded that we compare sensations with their occasioning causes without indicating how anyone could know about the occasioning objects independently of the sensations he supposed to be the sole basis of perception. I have tried to offer a theory of tactual knowledge which verifies Diderot's observations, extending them into a broad examination of depiction. I have avoided any theory of sensations which avers that they are separate from perceptions and much more limited than perceptions. Once sensations are broken off from perceptions and claimed to be the sole givens in sensitivity, it is impossible to establish a coherent basis for perception. When such a basis is given for perception, it must be rich in variety if it is to provide specific information about the furniture of the world around the observer (Gibson, 1979).

THE ISSUES AT THE CENTER

My task in this work has been to understand space, depiction, direction, and communication—especially tactual space, outline, perspective, and metaphor. I think we need a theory that uses force and resistance but produces shape, and the theory should indeed provide a base for perception; but that base should be a world and a medium and an informative set of variations,
not a set of sensations. The theory needs, however, to include a special factor. In some way, elements should be able to act as surrogates of spatial features spontaneously. They should create impressions of edges, axes, and shapes of certain types. The elements do not trigger sensations in the sense of a meaningless patchwork of areas. Rather, they capitalize on perceptual machinery that detects forms in depth in dealing with the real world. They stimulate perceptions of the edges and axes of these forms while simultaneously evoking perceptions of the Oat patchwork they form on the display's surface.

The research findings and theoretical discussions over the past eight chapters have attempted to satisfy many of the requirements of a theory of haptics and depiction. I have also entertained speculations on the edge of established fact. The issues at the very center of the discussion, however, can be demonstrated unequivocally by a few well-chosen figures.

Figure 9.1 shows an object in a special way. The contours that reveal the object are subjective, joining the termini of lines. The shape on which the subjective contours are based is a man's face. It is exactly the same shape found in figure 2.4—a man's face in strongly directional illumination. The shape of the subjective contours is a chiaroscuro (shape-from-shadow) form. The face is perfectly easy to see in the original, positive, patchwork display, which shows a face with deep shadows on the right side. In figure 9.1 the areas on either side of the subjective contours are filled with horizontal lines, with the same density and spacing on both sides of the contours. Overall, there is no brightness difference between the two sides of the contours. As figure 9.1 reveals, the result is that vision cannot perform shape-from-shadow analysis to recover the shape of the face. Subjective contours cannot stimulate shape from-shadow perception of the face.

Subjective contours are single contours. Figure 9.1 shows that the single contour with no brightness difference cannot support chiaroscuro analysis of the relief and illumination structure copied by the contour. Outlines also function as single divisions with no brightness differences in vision. Neither do they permit vision to analyze their chiaroscuro structure when they follow the laws of shape-from-shadow form. What outlines do well is copy the structure of tangible form. Figure 9.2 is a drawing of a man (by Pat; early, totally blind). Figure 9.2 shows that outline drawing is intelligible to touch.
involves use of tactile media, as well as contact with actual objects. It takes in information across time to detect objects arrayed simultaneously. The geometry of the objects that are found by touch is in principle the same as the geometry found by vision, so far as matters of direction and distance are concerned. Touch deals with energy, including vibratory energy as well as continuous pressure. It also deals with patterns. It gains information about a world through these patterns, and it is reasonable to expect that representational patterns, as well as patterns constituted by the objects themselves, could make sense to an observer using touch. These patterns can reveal intention, at times by contradicting reality, and observers who entertain intentions may be expected to consider the intended use or aim of a tactile representation.

Limits to touch include the amount of time touch needs to explore a scene. A survey of a scene is made more quickly by vision than by touch. This has led to the mistaken idea that vision is instantaneous. It is not: vision also takes time, and many samples, before it can survey a scene. The fact that touch takes time has also led to the mistaken idea that touch cannot yield an impression of an array of objects in space. Not so: touch yields an impression of a scene just as unequivocally as vision. Both senses take time to gain information about a spatial layout. The principle is clear, but much could be learned about how skillful deployment of touch is developed, how much of this development is spontaneous, and when it is best to offer training in mobility to the blind (Warren, 1984).

A key observation about vision is that lines in outline drawings depict features that are tangible. Outline does not trigger shape-from-shading or chiaroscuro processing. Most likely, outline processing occurs after chiaroscuro analysis. It may trigger axes and be governed by a general, amodal sense of space. Little, however, is understood about the physiological channels that allow its visual effects.

Blind children and adults recognize haptic pictures. Like nonpictorial peoples inspecting pictures for the first time (discussed in Deregowski, 1989), blind people are slow to recognize outline drawings on first exposure but do succeed handsomely after some moments, unaided. How much faster they may become with practice is as yet unknown. Given that touch is slow at some tasks compared to vision but faster and more accurate at others (Heller, 1989, 1991), there is reason to hope that they would become considerably faster. One should certainly not assert that first-time performance indicates the eventual limits on visual or tactile recognition of pictures, or that pictures are unsuitable for touch simply because first-time users have a laborious time.

Blind adults draw using lines in outline style, employing them for occluding boundaries and corners and as stick-figure versions of cylindrical forms.
The evidence indicates two barriers to drawing by the blind--low-rise barriers; one might call them, for they are not insurmountable. The first is the coordination of three factors, each of which is well understood in its own right, namely vantage points (and associated directions), object shapes (and facets facing a vantage point), and the picture surface (and its location between the vantage point and the object). Blind people do not usually comment spontaneously on how the shape on the picture surface can vary from a shape similar to the referent's (or an edge-on version of the referent), to a projective transformation, if a suitable vantage point is chosen. The second barrier is the drawing of familiar shapes of referents such as dogs, which, unlike utensils and furniture, involve silhouettes where curves vary systematically along the length of the curve. I have described this as the problem of distinguishing one species from another and providing distinctive information. Sighted people also meet these barriers to drawing development, and there is much to do to define the barriers properly, to show why they are so awkward and what routes lead past them.

The hallmarks of drawing development in the sighted can be discerned in drawings by blind children. The kinds of drawings blind children produce are indeed recognizable as drawings that would be produced by sighted children. The examples were obtained by asking blind children of various ages to make drawings. The hypothesis that blind children develop drawing skills along the same developmental course as sighted children could be supported further by following some individual blind children for, say, five years and noting how their drawing skills mature.

Blind people, children as well as adults, have a sense of the vantage point, but the use of the vantage point in drawing develops through several stages. Evidence from pointing tasks indicates that blind children do use the principle of convergence in pointing to an array of objects from close-up and far away. Evidence from tasks with drawings indicates that blind adults judge drawings using vantage points as developmentally later than drawings that do not involve vantage points. Also, drawings of objects using vantage point geometries are compared and ranked appropriately by blind adults.

Metaphor uses class inclusion and a violation of a rule to create an apt change, to communicate a referent, not simply to break the rules. Whereas young blind children make any mark stand for any referent at will, drawings by older children and adults use outline for relief features and follow configurational principles. These rules can be broken, but they are deemed to be rule violations by the person making the sketch. Reasons for introducing a rule violation include the belief that the referent lies outside the boundaries of outline drawing. At their best, the rule violations are not only motivated but also apt, that is, the shape being used is an appropriate one for the referent. It may borrow from another context, like a wake behind a flying bird, or another dimension, like a motion trajectory across time being drawn as a spatial line present at one moment and offered metaphorically as the shape of a wheel's spoke. Evidence from a study on motion indicators showed that blind and sighted people understood these motion indicators in much the same way.

Young blind children will use lines for any referent, but older blind people use the lines selectively, so that some of the uses evident in sketches from children appear in the drawings from their older colleagues only in the guise of metaphors. Thus, knowing about the sketch and the intended referent is not sufficient to establish whether the line is intended literally or metaphorically. The same problem arises in language: "A man is a machine" is not a metaphor if the speaker is a determined determinist. It is a metaphor if the speaker is an athlete who emphasizes that the body needs regular exercise. The proper classification of the vehicle of communication depends on intention.

Metaphor in pictures arises with intentional violation understood as a violation. Some contend that the blind mistakenly lump together both literal and metaphoric forms of depiction, claiming that blind people treat these equally. In chapter 7, however, I argued that the blind distinguish the two means of representation and resort to the metaphoric when literal depiction is understood to be unable to show a referent. I oppose the argument that literal and metaphoric pictures are on an equal footing for the blind--that they use drawings to convey ideas but not as a way of duplicating objects. Blind people, after an early stage where anything depicts anything, seek ways of drawing objects by shapes similar to the objects—indeed, many blind people have trouble drawing from a vantage point that entails a projective shape not similar to the object's shape. Correspondingly, metaphoric variations on shapes are often understood as violations of similarity.

Occlusion depiction gives rise to problems in recognition when the direction of occlusion is taken by the perceiver first one way, then the opposite way. These effects, known as figure-ground reversal (Rubin, 1915), were present for blind volunteers examining profiles depicted by lines. The implication is that haptic lines are not just taken by the blind as indicators of relief features, but rather they give rise to perceptual effects on which recognition can be based. Stick figures are also understood by the blind as they are by the sighted, in most respects, when allowance is made for vision's ability to decipher more detail in the stick figures. These studies are at present rather isolated experiments, and the range of application of the principles deserves attention. Figure-ground depiction is not the sole function of outline,
for outline depiction includes corners, wires, and cracks. The extent to which the Rubin findings (that outline gives rise to perceptual effects that control recognition) can be applied to all the outline functions is not known, but I suggest that each and every depiction function can influence recognition, and that each function effecting recognition in vision can also influence recognition in touch.

Chapter 8 also considered some directions that seem promising given the weight of evidence on outline pictures of objects and their significance for the blind. I argue that the ability to recognize outline drawing is universal. An octave relationship may have a status in vibratory touch like the outline's affinity for relief features. Art style may be taught to the blind with as much value as it has for the sighted.

Touch allows us to understand outline drawing without our having to be taught how to use it. Therefore pictures could help the blind to communicate. Outline pictures rest on the ability of a line to depict features of relief, an ability that comes late in the analytic pathways of vision, after purely visual matters such as shape-from-shading. Perception involves elements that generate experiences, and elements are restricted in their powers to evoke experiences. The perspective geometry of the world that can be used to make outline pictures is largely the same for touch and vision, including matters of convergence, vantage point, and occlusion. Consequently, drawing development occurs in a similar way in the blind and the sighted. Metaphor can be used in pictures since it rests on class-inclusion principles that can be invoked by any system of communication. Pictures with tropes make sense to the blind since blind people appreciate that a picture can contain an intentional rule violation. These are claims about properties of the human mind--the experience in perception created by outlines, the different geometries chosen to configure the outlines, and the appreciation of class inclusion and intention. All people share these universal properties of the human mind. They experience, represent, know, and intend.