Psychological state or a property of a surface other than shape? How can pictorial style be captured in nonvisual media? None of these topics have attracted diligent investigations. None of them can stand on their own as convincing experiments. But they map the stimulating ideological terrain that lies around the problems of line, form, and communication in graphic images. On occasion, they show us that the basic theoretical tools we need to undertake their further inquiry are not available at present. Consequently, the studies provide empirical stepping stones—an impressive path to as-yet unknown theories.

**FIGURE-GROUND AND PERCEPTUAL IMPRESSIONS**

The shape seen in an outline drawing can be the shape of a surface bounded by a line so that the shape acts like a profile, or it can be the shape of a line itself acting like a wire or crack or ridge. In this chapter I shall report studies on recognition of both these kinds of shapes in outline drawings.

An outline drawing can use lines to show a foreground surface ending at an occluding edge or boundary, with the foreground surface being to one side of the line and the background being on the other side. This is what Rubin (1915) called figure-ground perception. Rubin noted that the appearance given by the outline drawing can change remarkably if vision reverses its use of the line so that what was taken to be foreground becomes background and what was background becomes foreground. The picture remains physically constant during the perceptual reversal. What changes is the impression the perceiver has of the spatial layout depicted. The outcome is that one physical pattern gives rise to two different spatial impressions. This depicted space can change while the physical picture remains constant (Peterson, Harvey, and Weidenbacher, 1991).

In describing their reactions to pictures, blind adults from BOOST in Toronto have sometimes hinted at an impression of a spatial layout in addition to the flat surface of the depiction itself. Nat drew a balloon on a string as a circle and a line. Then he wanted to show that the circle was a mound or protuberance rather than a hollow, so he criss-crossed the circle with straight lines from rim to rim (fig. 8.1). The pattern would give the right impression, he said, if one felt the lines as a group instead of individually: "If you feel like with your hand--I can't explain it any other way--but if you feel--just get the general idea, you know, without caring so much about each line, you know, but just get the general feel of it--it should give you the idea of a three-dimensional thing almost."

Pat mentioned something similar as she drew a jar as two straight vertical
Fig. 8.1. Drawing of a balloon on a string, by Nat (early, totally blind). The interior lines give an impression of "a three-dimensional thing almost."

lines joined by a curve at the bottom (fig. 8.2): "I think from the bottom lines...it would give the illusion of roundness as opposed to a definite concrete...it would give an image of...to me I think it would represent an image of roundness as opposed to a firm, firm factual kind of thing. I think it's more of an illusion of roundness."

Another blind adult, Cal, drew the jar with central lines thick in the middle and thinning out toward the periphery (fig. 8.3). He explained this device: "Well, it just seemed to me that if you were concentrating--you know, if you were to put your hand on a jar just on one spot and you can tell just by putting your hand on that one spot that it does have that curved shape--it gives me the impression that the parts that are curving away from you on either side are lighter whereas the part that's right closest towards you would be heavier."

Nat, Pat, and Cal all may be saying that the feel of the picture can involve some kind of experience of three-dimensionality, roundness, or a surface receding into depth. Their language, however, is not conclusive on this point. Nat's mention of an "idea" of an object is vague, and Pat's "illusion" of roundness, like Cal's "impression," concerns the object as much as the device. It is hard to be sure which comments pertain to the percept, which to the device, and which to the referent. These difficult notions are worth pursuing because the basis of depiction is the fact that pictures allow us the perception of an object. A squiggle can change its appearance from time to time if we take it to depict a mountain range at first and then later take it to depict paint dripping down the side of a can. That the appearance of the line changes has been demonstrated in experiments on recognition. Rubin (1915) showed that if one side of a line or contour is seen as foreground on one occasion and the other side is taken to be foreground on a later occasion, often the display will not be recognized on that second appearance. That is, the foreground change can seriously impair recognition. Hence, the foreground and background relations seen in the display control the observer's attempts to identify whether the display has been seen before or not.

Rubin's experiment can be extended to the blind to show that the pictorial effects arising from haptic pictures are sufficient to affect recognition. Consider figure 8.4. It can look like a profile facing to the left or like a profile facing to the right. Notice that the depicted faces are quite different, although the line of course remains unchanged physically as the display alternates perceptually from one face to another. Ramona Domander and I presented raised-line drawings of profiles like figure 8.4 to blind volunteers and asked them to describe, say, the left-looking face; then a few seconds later the same display was given them with instructions to describe the right-looking face.
In our first version of the experiment, we planned a set of such trials to discover how long it would take a blind person to realize what we were doing. We initially expected that it would take at most a few trials before Scot (age 13, early, totally blind), the test subject, would notice that in each trial he was given the same display twice and that only the instructions changed. The alternative hypothesis was that a pictorial change in the referent controls recognition quite strongly in touch, and that Scot would not readily notice that an unchanging display was being described differently on each of its presentations.

The exact procedure was as follows. Scot was given a picture with a line running irregularly down the page. He was asked to imagine that there was an eye to one side—say, the left—at a particular location indicated by our placing his finger there. Then he was asked to feel the line, running his hand from top to bottom, slowly, and tell us where the facial features were—hair, brow, nose, mouth, and so on. The line was about 13 cm long. The maximum peak-to-trough height—the swing of the line from the tip of the "nose" to the recesses of the "mouth"—was about 3 cm. Then Scot was given a second picture, also said to be a profile, and he was asked to imagine the eye again, this time on the opposite side. Again, Scot felt his way along the line, identifying the features.

Next, Scot was given the test display. His task was to determine whether this display was "old," that is, one of the first two sheets of paper, or "new" if it was a different sheet. In the trials we presented "old" and "new" test displays in random order. The "new" displays, like the "old," had a wavy line with a dot that could be taken as a profile and eye. If the test stimulus was one of the "old" pictures, then it could be presented to Scot as either of the two profiles it depicted. Scot undertook 32 trials. In 16 the test display was "old," eight of these using the first profile he had been shown and eight using the foreground-background reversed condition. In 16 trials the test display was "new," half with a leftward-looking profile and half the reverse.

Scot scored 15 correct out of 24 in the "new" and "old" trials combined (nine out of 16 "old," and six out of eight "new"). In the foreground-background reversed condition only one correct response (an "old" display) was obtained in the eight trials ($p < 0.01$, if $p$ correct is 15 out of 24).

Scot called the displays "new" when they were foreground-background reversed. We asked him explicitly about this. He said that the displays seemed to him to be new sheets, new displays, not the same displays with the assignment of the eyes switched from one side to another.

Scot's results on the "new" and "old" combined are not terribly accurate—nine errors in 24 trials. And we were concerned that asking questions of Scot after the test, rather than giving him unambiguous instructions before the test, left some room for equivocation. We determined to test more subjects, with displays containing clearer differences and more elaborate instructions. Displays with clearer differences would increase accuracy on the "new" and "old" trials, and the more detailed instructions would emphasize that anytime a display reappeared it was to be called "old," even if the accompanying description had changed. To make the displays easier to distinguish, the features on some were drawn in a more exaggerated fashion: noses were enlarged, chins lengthened, brows drawn with more sweeping curves. The peak-to-trough height was about 6 cm. Both the displays from the previous experiment and the new enhanced displays were used in the present experiment. They were divided into three groups: the 16 most enhanced displays, the 16 least exaggerated displays (those with peak-to-trough height less than 2 cm), and the middle 16. Every trial used at least two of the three degrees of exaggeration.

To clarify the instructions, the subjects were familiarized with a display and expressly shown how an eye imagined to be first on the left and then on the right side of a line gives rise to two different faces. It was stressed that the same display—the same sheet—could come up in a test trial with the location of the eye changed but still be the same physical display. It was said
that this display should be called "old" rather than "new." Next came two practice trials, one "old" and one "new." A third practice trial ("new") was given to two subjects whose judgment had been incorrect on a practice trial.

In total, there were eight experimental trials; four were "old," two were "new," and two were "foreground-background reversed," with the order randomized. Again, half the presentation pairs had the imaginary eye on the left and half had it on the right.

The subjects were three girls and two boys, ages 8-14, tested in Calgary. Two were totally blind from birth, one had a pinpoint of vision, one could make out large print, and one had good vision until total loss of vision at age five. With the exception of the early-sighted child, neither the parents of the children nor the children themselves reported training with haptic pictures. The children's schools did not make pictures a part of the curriculum. The children were taught in regular schools, not segregated in a special school for the blind, so there would have been many opportunities to overhear discussions of pictures. But art classes did not seem to include picture making for the blind. As one parent put it after seeing some drawings made by her child on completion of this study, "Now our child can have her drawings up on the wall like everyone else." (One child, who appeared surprised at her own abilities with the displays, came back to me after I had tested her, knocked on the door of the testing room while I was working with another child, and politely asked if she could have some of the pictures she'd made to take home to show her parents that she could draw. On a cold Canadian winter day it warmed my heart to see her interest and surprise.)

In the six "old" and "new" conditions combined, three of the children scored six correct responses, and the other two made one error each. In the "foreground-background reversed" trials, all the subjects reported that all the stimuli were new (p < 0.01, since p of an inaccurate response is 1/6 per subject, estimating conservatively from the two subjects who made errors, and there are five subjects).

The first study, with Scot, was conducted cautiously. Scot was not told about foreground-background reversal. Our supposition was that if we told him about reversal and demonstrated it to him, he might try reversing the stimuli frequently and thereby frustrate the experiment. No warm up trials were given and everything hinged on Scot following our instructions properly. Surely, we thought, at some point in the 32 trials, which lasted about an hour, Scot would twig what was going on and the study would come to a halt. How long would it take? we wondered. Scot is an assertive boy, a competitive swimmer, free-spoken and confident. He commented quite openly on many aspects of our work with him. He would discern the manipulation after a few minutes at most, we thought. In fact, Scot apparently never discovered the trick. Discussions with him afterward included asking him point-blank if he thought we had ever given him an eye-reversed display in the test condition. He said no. When we explained that we had, he was amused and intrigued, and the displays seemed to become all the more interesting to him.

It is curious indeed that a display Scot saw once could feel to him like a new display a few seconds later on its second appearance. Motivated by Scot's results, the second phase of the study used stimuli that were much more differentiated and began by demonstrating that reversal could occur, using the demonstration to remove any question about the meaning of the instructions. Both parts of the study--one part using a long sequence of trials with no demonstration of reversal, the other using a demonstration of reversal to clarify instructions but few trials--suggest that pictorial foreground-background reversal can impair recognition by the blind.

As we visually inspect figure 8.4, we find that its "looks" change if we switch foreground and background. It is not like a graph line that remains the same whether we call it "mean monthly rainfall" or "median yearly income." To change the name of the line does not change its looks. Surely the change in looks, not any change in names, is responsible for the decrease in recognition that research has found with the sighted (Rubin, 1915; Zusne, 1970). The impression given by the foreground face seen after reversal can be quite different from the impression given by the face seen before the reversal. Our study found a change in haptic recognition when foreground and background were reversed. If the logic of the visual case holds, something analogous to the looks of the display may have changed. We might say that the feel or impression given by the display has changed.

What is the perceptual impression that may have changed? In vision, when we take a line to show foreground to one side, it results in one side looking far and the other near, the far side going behind the near, and in the case of profiles the foreground appears rounded rather than just flat. The referent of the line appears in perception; it is not just understood to be meant.

It is a rare sketch that puts in enough detail for anyone to be able to calculate the proper sizes, depths, and orientations of the objects in the array. So drawing relies on elements like line for its effects. It does not rest on patterns that are specific to calculable depths and slants. A drawing often presents just enough of a familiar object to tell us what kind of object it is, what species it belongs to. It may also be accompanied by a label or caption from the person who presents us with the drawing. Taking the caption along with the drawing, we know where the foreground and background are meant to be. If the elements in the drawing are suitable, foreground and background
are seen, not just meant, and the line can be viewed in terms of certain foreground-background relationships. The relations are seen as an edge without fooling us into thinking an edge is actually present.

The foreground-background relationships can be a flat object against a flat background or an empty space, or a rounded object against either background, or two surfaces coming together, both foregrounded, at a corner or crack. Or the line itself can be a foreground object like a wire or stick with background on both sides. What the study with Scot and the children shows is that mere squiggles can be taken to be foreground-background arrangements by the blind, and when the blind take the line this way, perceptual impressions arise in sufficient strength to control recognition. The effects are intense enough to impair recognition of a physically unchanging display returning for inspection after a mere few seconds’ absence. These strong impressions arise without the line being so detailed that it could be nothing but a face. I doubt whether many of our squiggles would be taken to be faces if we did not make the suggestion. Accordingly, lines seem to give impressions of edges of foreground objects to the blind without need of unambiguous, informative, perceptible detail.

An ability to take a line as a representation of a feature of relief, notably a foreground-background arrangement, is surely the crucial factor that enables sketches of objects to be effective in touch. It confers undoubted advantages. First, tangible edges and corners are the boundaries of the haptic world. The shape of the object is given not so much by heat, cold, texture, and surface qualities like oiliness but purely by the beginnings and ends of surfaces. If a line is not only readily taken to show an edge but also gives the feel of an edge, it can represent the basic shapes of the furniture of the tactile world in a perceptibly impressive way. Second, even a child can make a line be active perceptually in a drawing if the sketch does not have to be unambiguous. If the only ingredients needed for a picture are a squiggly line and an attempt to take it as depicting an edge, then a child can see or draw an imperfect, simplified version of part of the object and successfully will it to be depicting a foreground-background arrangement.

The will to depict is evident in a blind child’s list drawings, where by fiat a mark stands for an individual feature of an object. A perceptual experience of depiction probably follows hard on the heels of list drawings, for quite young blind children use outline for individual features of objects. It makes sense that first would come the will to depict and the use of fiat, then the use of outline. But on the limited evidence available at present it is by no means certain yet which comes first, fiat or perceptual experience of depiction, and some five-year-old blind children making drawings switch from one to another and back again within a few minutes.

**STICK FIGURES**

Once the blind recognize that the line gives suitable impressions, this can provide a base for further development of drawing skill. Some of the development of drawing concerns the scope of outline. Relief foreground-background arrangements work well, but some other referents do not. Pain, noise, and smell, for example, are judged by the blind to be unsuitable for line depiction. Presumably, the reason is that line gives definite impressions of the edges of surfaces of objects, but when the will to depict tries to mold an experience of pain, noise, or smell around the tangible line, no suitable impression arises.

In searching for uses of line, a moment may come when the adult or child realizes: I have reached the limits not of myself but of the line. The person may test in his or her own perceptual experience and find one use of line appropriate and another inappropriate. A line cannot depict the boundary of a pain in a finger or a tingle of excitement in the hands and feet or a knot of anxiety if it does not create a perceptual impression that simulates pain or anxiety. But outline drawing has an additional component besides the line itself, and that is the pattern. What cannot be achieved as a perceptual impression let loose by the line can sometimes be indicated by the pattern. Patterns can suggest not only affect but also complex attitudes and relationships. Kathy N. (early, totally blind), for example, volunteered to draw a raised-line picture of marriage (fig. 8.5). She drew linked pairs of small circles. The pairs are sometimes close, sometimes apart. Sometimes the links have dots on them representing children. The pairs are surrounded by a corral with a gate. The gate’s handle or lock is on the inside; the implication is that marriage is a voluntary bond.

Outline drawings can show states and relations by depicting scenes of various kinds. The line in each part of the scene can stand for a feature of surface layout, and the layout can be arranged to indicate a psychological state. Sighted people see pictures suggesting states such as sadness or pride, or roles such as mother or father, or relations such as someone leaving someone else. If blind people are to make effective use of pictures, the psychological states, roles, and relations that pictures can express to the sighted need to be conveyed to the blind as well. One highly economical device for doing so is the stick figure. A scene containing a few people drawn as stick figures and depicted in various postures can convey moods...
respectively). The early blind subject with total vision loss at age 12 was Scot, from Calgary, tested at age 13. The remaining blind subjects ranged in age from 23 to 31. All had participated in at least one previous study of ours. We also included 13 sighted children, ages 7-11, at a public school, testing each of the sighted children individually with inkprint versions of the figures. Sixteen sighted undergraduates at the University of Toronto also participated in the study.

The figures were highly abbreviated line drawings, so schematic that we decided to call them "twig figs" since they are even more stripped down than most stick figures. Being schematic, they have the advantage that they are easy to explore in touch within a few moments. They comprise a small oval for the head, then a long line for the body and then a short horizontal line for the feet.

We told our volunteers that the twig figs stood for people, in pairs, engaged in various actions. The twig figs were arranged in contrasting pairs. We said, in each trial, "Here are two pictures. In each picture there are two people. One pair of people is doing X. One pair is doing Y. Which is which?" So for each set of figures, subjects were given labels and asked to judge which label best fit which pair of twig figs.

There were six pairs of pictures, each picture containing two people (fig. 8.6). The pairs were given in different orders. Every twig fig was always paired with the same partner. The labels were:

1. A pair of people talking vs. angry people
2. Two old people vs. two sad people
3. Two proud people vs. two polite people
4. One person walking past another vs. one person walking behind another
5. Someone who has just seen a pretty girl vs. someone leaving another person
6. Mother and child vs. father and child

Agreement on the assignment of the labels was high (table 8.1).
Agreement among the children was 95 percent, with three pairs of pictures reaching 100 percent agreement. The sighted adults agreed with the majority opinion among the children 85 percent of the time, with two pairs of pictures reaching 100 percent agreement. The blind agreed with the majority reactions by the sighted 77 percent of the time (early blind 76 percent, late blind 79 percent). Only for walking past/walking behind was there 100 percent agreement by the blind. For another three of the judgments (old/sad, polite/proud, leaving/seen a pretty girl) there was agreement by 13 of the 15 blind respondents.

On one judgment the blind generally concurred with the sighted but with caveats. The angry/talking pair was ambiguous, several said. They noted that the people leaning together could be intense and angry, or could be very...
sighted ate. If there is any universality to the poses used to express feelings and intentions, it should be possible for the blind to interpret schematic postures much as the sighted do. This means that these ideas can be depicted and not just enacted when discussing them, for instance, with children. It is important and useful that these postures can be drawn in brief, bare figures that communicate to the blind as they communicate to the sighted.

**UNIVERSALS OR CONVENTIONS**

The twentieth century has produced a store of critical thought about how pictures function, how pictorial skills developed through the ages, and what constraints pictures operate within. In Gombrich's (1974) words, it is important to clarify the potential of the image in communication, to ask what it can and cannot do. Pictures not only show us objects; they also allow us to transform ideas and metaphors into useful images. Previous chapters have explored the line standing for relief edges, organizational principles of spatial representation, and the deployment of deliberate errors. Here I shall examine the thesis that many aspects of pictures are conventions, varying from society to society, rather than universals.

Fundamentally, there are two conceptions of pictures. One idea is that pictures are products of social forces that are more profound than the tides of fashion. The convention thesis is that technology, education, and popular culture work together to modify the beholder's reaction to pictures. Together, these influences are thought to control much more than the beholder's preference for one genre or style of pictures. In theory, they control the beholder's ability to recognize what any picture depicts. The convention theory is supported by comments from European travelers in regions with little contact with technology, who offer rather ethnocentric reports such as "Take a picture in black and white and the natives cannot see it. You may tell the natives: 'This is a picture of an ox and a dog,' and the people will look at it and look at you and the look says that they consider you a liar" (Laws, quoted in Deregowski, 1989). Marshall Holmes, an educator in Ethiopia in the 1920s, interviewed in 1980, reported to me that he found that rural Ethiopian villagers could not recognize highly detailed realistic black-and-white drawings of local flora and fauna on first examination of the pictures.

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**Impressions and Universals**

**TABLE 8.1 Identifications of "twig figs."** The percentage given is the agreement with the majority decision by the children.

<table>
<thead>
<tr>
<th>Pairs of Pictures</th>
<th>Sighted Children</th>
<th>Blind Adults and Teenagers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angry or talking</td>
<td>100</td>
<td>73</td>
</tr>
<tr>
<td>Old or sad</td>
<td>92</td>
<td>87</td>
</tr>
<tr>
<td>Polite or proud</td>
<td>92</td>
<td>87</td>
</tr>
<tr>
<td>Walking past or behind</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Leaving or seen a pretty girl</td>
<td>100</td>
<td>87</td>
</tr>
<tr>
<td>Mother and child or father and child</td>
<td>85</td>
<td>27</td>
</tr>
</tbody>
</table>

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friendly, indeed deeply interested in one another. Their alternative response to the figure makes visual sense, I would judge. The alternative pair can seem coldly hostile, as though standing erect stiffly.

On only one of the six figures did the responses of the blind depart noticeably from those of the sighted: father-child/mother-child. The blind said that the father-child figure was hard to make out, and it was often interpreted as a small-headed adult holding a baby with a large head, at chest height—that is, at the breast. The adult's head was taken to be the child's and vice versa. With this tactual impression in mind, we tested eight blindfolded sighted undergraduates, giving them the tactual pictures under the same conditions as the blind. Seven of the eight made the same assignments of the father-child/mother-child figures as had the blind, that is, the opposite judgment to that of the sighted children and adults in the tests based on vision.

Overall the agreement among the blindfolded students with the majority opinion of the sighted children and adults was 69 percent. The blind rate of concurrence (77 percent) with majority opinion is midway between that for the blindfolded (69 percent) and that for the sighted adults (85 percent) and children (95 percent). This result is good evidence that the basis for these judgments is as available to the blind as to the sighted.

In sum, the blind and the sighted agree substantially on the interpretation of twig figs. The one exception is due to faulty discrimination of shapes, which could be rectified presumably by enlarging the figure.

The schematic figures here show events, relations between people, moods such as sadness, and traits such as pride. Evidently touch is an appropriate sense for depicting a range of scenes with psychological significance.

The blind are as interested in moods, relations, and dispositions as the sighted are.
Deregowski (1989) noted that the pictures that were initially abstruse to people from nonpictorial cultures often became recognizable after a few minutes' inspection. Tutoring was not necessary. Holmes made the same observation to me. The villagers, he observed, would recognize the pictures spontaneously after a while. Hence the convention thesis is untenable. If it were taken to the extreme—a transport that some scholars have in fact advocated—the convention thesis would hold that every aspect of pictures rests on a learned convention, and spontaneous recognition would be impossible.

Goodman (1968) is often alleged to hold an extreme convention thesis. He argues that realistic representation depends "not upon imitation or illusion or information but upon inculcation" (p. 38). He qualifies his position to a degree, saying that "almost any picture may represent almost anything" (p. 38), with some hedging by the term almost. He also notes that "judgements of similarity in selected and familiar respects are...as objective and categorical as any that are made in describing the world" (p. 39). But despite these cautions, he is an enthusiastic conventioneer in asserting "just as a red light says 'stop' on the highway and 'port' at sea, so the same stimulus gives rise to different experiences under different conditions" (p. 14); and so far as depiction is concerned, "the behaviour of light sanctions neither our usual nor any other way of rendering space" (p. 19). Related arguments are made by Herskovits (1948) and Steinberg (1953), and there is a consistent line of allied arguments from Wartofsky (1977, 1980), who asserts emphatically that pictures are seen as convention dictates and in turn pictures help shape our perception of the world.

When we consider a simple line drawing and see a foreground object set against a background, this is due to some convention we have learned in childhood, the extreme convention theory holds. The thesis is that physically lines are not found at the edges of objects, hence to identify one with the other is learned. When observers examine a picture and see depth represented systematically, following a perspective system, a convention theory tells us that we are obeying just one of many possible systems, all equally valid (Goodman, 1968), and this one system we have adopted merely out of social consensus. Kubovy (1986) points out that artists often use a projective system that contains compromises, departures from exact perspective. Goodman notes that this could be used as support for the convention thesis. An alternative explanation is that the compromises indicate strong biases in vision, limits to the extent that untutored vision can follow the laws of perspective (almer, 1943; Pirenne, 1970; Nicholls and Kennedy, 1991).

The convention thesis can go beyond the analysis of line elements and perspective systems. When we take a concrete picture to symbolize an abstract idea, the convention thesis can continue to argue that this is as much a convention as the adoption of a logo, emblem, or mascot. Further, when a picture shows a quality such as hard or soft, or a mood such as anger, this would be interpreted by the extreme thesis as due to education in a convention, much as white symbolizes simplicity in some cultures and mourning in others.

I have argued in the preceding chapters that the evidence from the blind supports a diametrically opposed conception of pictures. In this radically different theory, pictures are products of capacities of the human mind that are not specifically taught. In the use of outline, vantage point, and metaphor the blind reveal abilities that are not conventions taught to them prior to their use.

Brian Molyneux (1980) of the Royal Ontario Museum, following the work of Selwyn Dewdney (1970), an early student of Canadian Indian petroglyphs or rock-face paintings, noted the universality of recognizable pictures in the rocks and caves of prehistory. He observed to me that on every site he had inspected there were always some pictures he recognized. No matter whether it is located in Europe or Africa or America or Australia, early "parietal" art (art found on rock faces) is often recognizable by untrained contemporary observers (Kennedy and Silvers, 1974). The modern eye can often tell what the lines and contours stand for without instruction or prompts. There are sites on every continent where the flora and fauna of the cave artist's time are plainly identifiable. The cave artist's language would be uninterpretable to the uninitiated, but the daubs use a means of communication that is universal.

It seems unlikely that picture making could have been invented in one place as a set of graphic conventions and then spread throughout the prehistoric world, all the while retaining the system of conventions. More likely, cave artists in separate antipodal communities discovered the laws of visual representation independently. The same laws of perception and cognition were discovered at each site. The prehistoric artists found that tracings in the earth could look like a disparate referent. Their companions were shown the discovery, not taught what it meant.

Evolution has produced a species that uniquely can make and interpret outline pictures. Evolution achieved this end even though there was no evolutionary pressure to make pictures. Interestingly, the making of pictures was not initially inept, only improving very slightly, gradually, with each succeeding age. There is no fossil record of pictures gradually improving in likeness across aeons. The making of pictures did not confer an advantage that selected one species over another. Rather, the capacity to understand
depiction is an evolutionary spin-off. It is an example of a complex skill universally present in contemporary humanity that has had no role in evolutionary selection. Its latent presence for vision was discovered more than 20,000 years ago, but its latent presence for touch is being discovered only today. Derekowski (1989) notes that nonpictorial peoples such as the Tallensi of Africa are able to draw at first attempt. He provides appropriate illustrations of a man, a woman, a horse and rider, and a crocodile, all in stick-like form, from the Tallensi. Likewise, I have reported here that the blind are capable of making similar kinds of drawings on request or at their own initiative.

Evolution is capable, the evidence indicates, of producing talents that are not honed over millions of years, as there is no trace of their evolution before modern man. These abilities have not given an advantage in evolution, though components of the ability may have been subject to evolutionary pressure and gradual improvement. In addition, the ability from which a talent has emerged as a spin-off may have undergone gradual evolution. But a functioning ability can emerge fully fledged without a gradual process of improvement and selection, as a result of a good fit of previously independent components, or a spin-off that is latent in an ability with its own particular function.

The sudden emergence in evolution of an ability such as depiction is not likely to be an isolated instance. Other species may show confluences of abilities that produce new, coherent, useful capabilities with no evolutionary history of use. In humans, we developed a dear intuition of infinity long before the idea could be put to practical use in physics. The intuition itself cannot have come into being by gradually counting larger and larger numbers, as it would take forever to count to infinity. It is appreciated by realizing that in principle counting has no preset limit. Most children realize this without explicit tuition. At about age 6-8 years many children observe phenomena such as pairs of mirrors reflecting each other, or pictures containing pictures of pictures, and understand without any prompting that this sequence continues forever.

Whether it is a spin-off or the result of a confluence in evolution, outline perception piggybacked on a perceptual activity that presumably did have an obvious advantage in evolution. That activity cannot be color perception, since outlines work well in black and white. It cannot be motion perception, since static pictures work well, or binocular vision, since monocular displays are also easily recognized. It is unlikely to be object recognition, since schematic and novel objects can be shown in outline, and outline functions control object recognition in Rubin’s foreground-background experiments. It must be a perceptual system that deals with edges, comers, and wire-like objects. Clues to the relevant faculty may be found in the characteristics of axes. One hint is provided by axes that do not conform to the contours of outlines. Axes can be asymmetrically positioned between contours, figure 8.7 shows.

In figure 8.7, a convex corner is perceived lying close to one of its flanking contours and considerably farther from the other flank. The cube depicted in the figure appears to have been painted at that corner, with a thin stripe on the top surface of the cube and a wider stripe on the vertical surface. The axis divides the narrow stripe from the wide stripe. The two contours flanking the axis help to show the location of the axis. The axis is also defined by the lines indicating the other corners and edges of the cube. If the two contours come closer and closer together, eventually they will simply form a thin line or outline. The appearance of a stripe painted on a surface becomes just an impression of a corner, and the contours are seen but not used as borders in themselves. The principles of axis formation may, however, be essentially the same for a thin line and the wide line of figure 8.7.

What figure 8.7 suggests is that contours are used to define perceptual features lying between them. The features can be axes, which can be perceived as comers or occlusions. But moreover, in wide lines the contours define surfaces and characteristics of surfaces stretching between the contours.

Contours can often determine the shape that is perceived between them. A black circle can be seen as depicting a shiny sphere if the circle contains a small white patch functioning as a highlight. A silhouette can indicate the shape of the surface within the border of the silhouette (fig. 8.8). Vision can extrapolate the locations of surfaces and comers from context and flanking contours. So too can touch. If the fingertips rest on a surface of a table, that surface is only contacted at a few locations, but it is perceived as a flat,
exercise of these abilities. If the evidence from the blind is a good guide, then these abilities should be dormant but available via routes that bypass the blocks.

One case in point is music for the deaf. "Pictures for the blind" seems superficially like an oxymoron, and so does "music for the deaf." But it is a matter of everyday observation that rhythm, an important aspect of music, is available to touch. For some time, schools for the deaf have commonly included rhythmic exercises in their pedagogy. I have recently met an elderly Toronto engineer who designed a floor almost six decades ago for use in a school for the deaf. The floor transmitted rhythmic drumbeats and other tangible percussive events.

Music consists of rhythm and tonal events based on the octave. The octave is a relation between vibrations. A tone of $x$ cycles per second (c/s or Hz) has as its octave a tone of $2x$ Hz and higher octaves at $3x$, $4x$, and so on. Touch can discriminate vibrations as well as rhythm. Hence, there may be an octave relationship that is significant in vibratory touch. In audition, each note and its octave form a pair with a noticeable affinity. Hearing an octave has an effect on untutored children and even animals (Blackwell and Schlosberg, 1943; Winner, 1982). The relationship can best be described as one of affinity, not just similarity, since if the two notes are played one after the other, the change in the note is evident. If the relationship were merely one of similarity the change would be hard to discern, like playing 100 Hz and then 101 Hz, a change of only 1 percent. Rather, the octave relationship can be described as an affinity, in which the two tones are grouped as a related pair. They may perhaps be described as easy to compare or as having similar functions.

Since the two tones in an octave pair are related but different, the octave has properties like outline and abrupt changes in relief. In each case, there are striking perceptual affinities without the members of the pair appearing identical. Since outline-relief pairing is present without tutoring in both vision and touch, it is reasonable to suspect that the octave relationship might be present without tutoring in both audition and touch. Just as touch can discern relief and raised lines, it can discern vibrations in surfaces.

Touch is capable of detecting vibrations from about 10 Hz to about 1000 Hz, with greatest sensitivity around 250 Hz (Sherrick and Craig, 1982). In monkeys, three nerve fibers have been found that favor different frequencies (Loomis and Lederman, 1986). A slowly adapting fiber roughly favors 20 Hz, a rapidly adapting fiber centers on 40 Hz, and the Pacinian fiber is likely most sensitive to 250 Hz vibrations. Discrimination between different vibratory rates or haptic tones is not well understood, especially in the handicapped (Warren, 1984, pp. 50-51), but certainly it is possible to make some distinctions between tones within the range of sensitivity. Tones much below 10 Hz
probably are perceived as individual pulses, and tones above 1000 Hz are most likely discerned as onsets, quiet durations, and cessations rather than continuous tones.

Many of the notes in the lower half of the piano make a clear impression in touch, as one can check informally by placing a hand on the piano. Middle C is about 261 Hz, and the lowest note on the piano (an A) is 27.5 Hz. Thus, much of the range within which music is played is significant for touch. To test whether the octave is relevant to haptics, notes within the mid and lower ranges of the piano can be used. A vibration of 60 Hz can be compared to its octave, 120 Hz, and to notes straddling the octave, near 120 Hz. Comparisons between two tactile vibrations might be governed by their closeness in frequency. If so, 60 Hz would appear virtually identical to 70 Hz, close to 80 Hz, fairly distinct from 120 Hz, and quite different from 160 Hz. Alternatively, it might be that along with differences in frequency, tactile perception is affected by octave relations. If so, comparisons between 60 Hz and 120 Hz would be facilitated, as against comparisons between 60 Hz and notes around 120 Hz, such as 103 Hz and 137 Hz. These differ from 120 Hz by 17 Hz, a prime number which does not evenly divide into 60 Hz, and thus they are incommensurate with the simple octave relationship.

Ruth Schuler and I devised a test for use with the deaf to determine whether the octave relationship had a special significance in vibratory touch. Six profoundly deaf and four hearing-impaired volunteers were tested (table 8.2). The volunteers were recruited through a center for deaf adults in Toronto where Schuler was a staff member. Her communication with the profoundly deaf was chiefly by sign language and written cards, although occasional use was made of speechreading (“lipreading”) and, in the case of the hearing-impaired who used hearing aids, spoken language.

Four of the profoundly deaf were congenitally deaf with no known hearing. One became deaf at three weeks as a result of measles and the other at three years as a result of meningitis. All of the profoundly deaf communicated by sign language. One (George, age 73) has had some instruction on a musical instrument, a piano. None of the profoundly deaf used hearing aids. They had no known auditory capabilities. All of the profoundly deaf had had seven or more years of schooling. None had any college-level education.

All of the hearing-impaired volunteers normally used hearing aids, but for the purposes of this test these were set aside and industrial hearing protectors were worn to further block out any extraneous sound from the tone generator. Each of the hearing-impaired had had a minimum of four years education and one had had three years of education beyond high school as a nurse. None had had formal training in music, though Rose (age 82) had played piano without
TABLE 8.2 A study on the ability of the deaf to differentiate tones as tactual vibrations. Errors on same/different tests given pairs of tones.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Age</th>
<th>Onset</th>
<th>Pairs of Tones (Hz)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Different Tones (max 12 trials)</td>
<td>Same Tones (max 5 trials)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>60/103</td>
<td>60/120</td>
<td>60/137</td>
<td>60/60</td>
<td>103/103</td>
<td>120/120</td>
<td>137/137</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profoundly Deaf</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winifred</td>
<td>69</td>
<td>birth</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>Florence</td>
<td>60</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>George</td>
<td>73</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Ruth</td>
<td>61</td>
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<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
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<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mabel</td>
<td>66</td>
<td>birth</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing Impaired</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>83</td>
<td>40</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Cora</td>
<td>77</td>
<td>67</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rose</td>
<td>82</td>
<td>?</td>
<td>6</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td>34</td>
<td>8</td>
<td>31</td>
<td>13</td>
<td>14</td>
<td>12</td>
<td>10</td>
<td></td>
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<tr>
<td></td>
<td></td>
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<td>60/90</td>
<td>60/120</td>
<td>60/150</td>
<td>60/60</td>
<td>90/90</td>
<td>120/120</td>
<td>150/150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roley</td>
<td>61</td>
<td>?</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total with Roley</td>
<td></td>
<td></td>
<td>11</td>
<td>13</td>
<td>13</td>
<td></td>
<td></td>
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</table>
Impressions and Universals

An 80 watt Sony speaker diaphragm (range 20-20,000 Hz) was mounted in a wooden speaker box 27 cm by 27 cm by 35 cm. Pure sine wave tones, recorded on a cassette tape, were played through this speaker. The box was held with the 35 cm by 27 cm base resting on the seated volunteer's thighs and the hands placed on the sides of the box with the forearms touching its sides. The diaphragm faced away from the volunteer, that is, it was out of sight, and the rear of the box was in contact with the volunteer's abdomen.

Each trial involved a comparison between a pair of tones presented successively. The tones lasted five seconds each, and there was a 10-second blank interval between the two tones. The volunteers judged whether the two tones were the same or different. To clarify the procedure, the volunteers were given six pretrials. The first pretrial involved a 120 Hz tone followed by another 120 Hz tone, which the volunteer was told were the same. Then a 60 Hz tone and a 250 Hz tone (which the volunteer was told were different) were presented. There followed four more pairs: 90/90 Hz (same), 60/137 Hz (different), 150/150 Hz (same), and 60/103 Hz (different). The pretrials were used to adjust the vibration intensity levels to a level where the volunteer indicated the tones could be felt but, in the case of the hearing impaired, not heard.

The experimental trials included 36 "different" pairs (12 trials each at 60/103, 60/120, and 60/137 Hz). On half, the 60 Hz tone was presented first and on half it was presented second. There were 20 "same" trials (five each at 60/60, 103/103, 120/120, and 137/137 Hz). The distribution of the pairs was random. One subject, Roley (hearing-impaired), was given 90 Hz and 150 Hz tones instead of 103 Hz and 137 Hz before we realized it would be better to depart from the octave at 120 Hz by a prime number such as 17 Hz. For completeness, the data from Roley were reported in table 8.2.

The volunteers were in error on 49 of their 180 "same" trials (with a range of 22 percent error on 137/137 Hz pairs to 31 percent error on 103/103 Hz pairs). Evidently there is nothing distinctive about 60/60 Hz pairs (28 percent errors) and 120/120 Hz pairs (26 percent errors). Roley made only one error on a "same" pair, and that was on the 120/120 Hz pair.

Only 8 errors (7 percent) were made on 60/120 Hz pairs in 108 trials (11 errors out of 120 trials, Roley's data included). By contrast, there were 34 errors (31 percent) on 60/103 Hz pairs and 31 errors (28 percent) on the 60/137 Hz pairs. All but one volunteer with tied scores made more errors on 60/103 Hz pairs than on 60/120 Hz pairs (p < 0.01, binomial, one-tailed). All but one volunteer made more errors on 60/137 Hz pairs than on 60/120 Hz pairs (p < 0.05, binomial, one-tailed). The 60/120 Hz scores are less than the mean of the 60/103 Hz pairs and the 60/137 Hz pairs for all of the volunteers except one, whose data are a tie (p < 0.01, binomial, one-tailed). Roley's data fit the pattern.

The results show that the octave holds a special position in vibratory touch. Judgments of the octave pair are more accurate than judgments of tones straddling the octave. Judgments of the octave pair (60/120 Hz) are more accurate than those of tones that are less distant in terms of frequency (60/103 Hz) or more distant in frequency (60/137 Hz). Further, accuracy in judging identical tones to be the same in the range 60-137 Hz is less than accuracy in judging 60/120 Hz to be different. Schuler noticed that the deaf described the judgments of the 60/120 Hz pairs as comparatively easy. The deaf described themselves as especially confident about their judgments of these pairs, and they responded more quickly to these than any of the other pairs. Schuler observed that the facial expressions and body gestures of the volunteers indicated confidence with the 60/120 Hz pairs and uneasiness with the others. The volunteers often described their judgments on the nonoctave pairs as guesses.

One might describe the 60/120 Hz pair as easily grasped for purposes of comparison. The relation between the tones in the pair is quickly evident to touch. Given a time interval of only ten seconds, the relation between the vibrations allows accurate judgments of the tones. An implication of the results is that the affinity between the members of the octave pair could produce quite different results if the interstimulus interval were lengthened. There might eventually be a kind of auditory deception, a trompe l’oeil. That is, if the interstimulus interval were lengthened, say, 60 seconds, the affinity might be taken as similarity. In that case, judgments of octave pairs should result in more errors than judgments of nonoctave pairs.

Descriptions of the deaf participating in music programs, learning to play musical instruments, and enjoying dancing are now available in articles and texts from educators (Birkenshaw, 1965). The unique contribution of the present study is its implication that the octave may be present in vibratory media. There are important analogies between this result and the use of outline by the blind. It is possible to build significant patterns with outlines, meaningful to untutored observers, blind and sighted. So too it may be possible to create significant patterns with octave relations which are equally appropriate for untutored auditory or tactile listeners. In vibratory media the patterns would be chords, if they are simultaneous, and melodies, if they are
sequential. The deaf, using vibratory touch, may be able to distinguish between coherent chords and random assortments of notes. They may be able to tell simple melodies from random sequences of notes. They may even be able to distinguish combinations of sound that express cheerfulness and those that express sadness, emotions often associated with major and minor keys. They may be able to distinguish complete from incomplete melodies. If so, they may be able to distinguish increasing tension as melodic lines depart from a home key, and release of tension as the lines return home.

All of these relations built on octaves offer the promise of being universals in music, and they may be available to a central vibratory sense that is accessible through touch as well as audition. I should add, as a cautionary note, that data from the hearing-impaired cannot distinguish between vibratory touch serving as a channel for bone conduction to the ear and vibratory touch per se working independently of the auditory nerve. My hypothesis is that there is an octave in both kinds of vibratory touch. It is more radical to suggest that there is an octave in vibratory touch per se, but the data are equivocal on this point. The data from the congenitally deaf indicate that the octave’s special status arises without any need for instruction.

The analogy between the octave and the outline’s affinity for features of relief is interesting and provocative. Each is the basis for perception of structures. The octave is the basis for harmonic structures (Winner, 1982, p. 230). The outline’s affinity for relief is the basis for depiction of structures made of surfaces. The analogy has clear limits because the rules for combining the dents are different for vibrations and surfaces. The structures for vibrations are “harmonious” if they consist of vibrations with ratios 1:2 (the octave itself), 1:3, 1:4, etc. (the overtones or higher octaves). The structures for surface relief are not ratios. The structures of surfaces are possible or appropriate if they consist of conjunctions that follow the laws of the physics of surfaces (Kennedy, 1974a). At no region along its length can a wire (space on both sides of a thin cylinder) turn into a crack (empty space between surfaces). The wire must have a termination. The surfaces on either side of the crack must have edges. But an occluding boundary of a mountain’s rounded surface can become at any region along its length an occluding edge of a flat surface such as a cliff. In short, surface features have types that can and cannot adjoin. The combinatorial rules for vibrations use ratios and for surfaces use types.

Vision does use ratios—in fractals and in judgments of proportions. The vibration sense does use rules for combinations of sounds, especially in perception of speech. It also can give an impression of impossible combinations, just as drawings of surfaces can show impossible combinations, for a set of pitches can seem to increase in frequency ad infinitum. This may be as effective in touch as in audition. But the perception of representations of surfaces as possible and the perception of notes as harmonious use different bases for judgment.

There is an important logical difference between perception of harmony and perception of acceptable surface combinations, in addition to the mathematics defining the structures of the dents. Any combination of vibrations can be presented to the perceiver. Inharmonious selections are as physically possible as harmonious ones, but only some combinations of surfaces are physically possible. Therefore, the distinction between harmony and discord is a psychological one at heart. The distinctions between combinations of surfaces is a physical one that allows no compromises.

**PERCEPTUAL STATES**

The difference between a psychological base and a physical one has great force when the study of depiction attempts to encompass matters of metaphor, expression, and style. In examining drawings showing a terrain, physics provides an objective check on what is correct and incorrect, and the mathematics of perspective defines correct arrangements and proportions. In some metaphors, the domains being depicted involve translations between physically measurable dimensions such as space, time, and distance or physical features such as shape and location. But some metaphors involve crossing into perceptual domains where it is impossible or unclear how an experimenter could measure dimensions independently of the volunteer’s own perceptions.

Metaphors of pain or numb feelings are a case in point. Morton Heller, Paul Gabias, and I have tested blind adult volunteers on drawings (fig. 8.9) suggesting motion, pain, and numbness. The drawings consist of four sketches of a hand in outline, with the lines for the fingers and the side of the hand standing for the occluding bounds of rounded surfaces. The thumb varies from drawing to drawing. In one, the outline of the thumb consists of dashes. In the other three, the outline of the thumb is complete, but extra lines are added as graphic devices to suggest various states. In one, five short straight lines radiate from the thumb. In the second, five short arcs surround the thumb. In the third, five short arcs cut across the thumb.

Volunteers in this study were asked to decide which drawing showed a hand with a thumb in pain, numb, moving in a circle (like twiddling one’s thumb), and moving back and forth (like someone flexing the thumb, in the same plane as the palm and the fingers).

Twelve sighted undergraduates, from the University of Toronto, ages 19-24, tested independently, identified the drawings by sight. To 11 of them, the
TABLE 8.3 Blind adults' judgments of devices indicating states of the hand.
On four occasions the subject did not select one of the options offered.

<table>
<thead>
<tr>
<th>Possible Referents</th>
<th>Pain</th>
<th>Numb</th>
<th>Thumb Circling</th>
<th>Thumb Back and Forth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiating lines</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Dashed outline</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Arcs surrounding the outline</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Arcs cutting across the outline</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

Volunteers, the same referent was said to be shown by two devices. Six of the volunteers concurred entirely with the majority decisions (two of the congenitally blind, four of the later blind).

In identifying which figure showed pain and which showed numbness the majority of the blind concurred with the sighted. The blind also concurred with the sighted in judging that the two drawings with arcs show motion, but they attributed opposite meanings. The blind often took the arcs around but not crossing the thumb as indicating a complete circle, and understood the arcs across the outline as indicating motion of the thumb only along the length of the arc. The sighted (and some of the blind) took the arcs surrounding the outline as indicating partial silhouettes of the thumb in various locations distributed to the left and right of the outline in the plane of the picture and the palm. The arcs across, some of the sighted supposed, indicate breaking out of the plane by a line of motion breaking the outline. Thus, there are equivocal procedures for relating the device to the referent, and for reasons that are as yet unclear the blind may select a different procedure from that chosen by the sighted.

The evidence in previous chapters suggests that the disagreement with the sighted is not likely to be in understanding shape or motion or how to use an outline' of the thumb itself. Hayley Naor and I tested 20 blindfolded sighted subjects ages 8-58 (mean age 27, s.d. 14.1) at the Ontario Science Centre, asking them to examine the displays by touch. The majority (12 of 20) said that pain is best shown by the radiants and numbness by the dashed outline (13 of 20). On the thumb-circling referent they were split between arcs cutting across (eight votes) and the arcs surrounding (nine votes), with three selecting other options. There was a similar split concerning which figure

dashes meant numb, the radiants meant pain, the arcs across meant movement in a circle, and the arcs surrounding meant back-and-forth movement.

The 17 blind volunteers who participated in this study were adults recruited in North Carolina, New York City, Baltimore, and Ottawa. They were given tactual versions of the figures examined by the sighted volunteers. Nine were congenitally blind (one had low vision and the others were totally blind) and eight were later blind (one had light perception and the others were totally blind). All had participated in at least one previous study on depiction. None, however, had dealt with pictures showing pain or numbness with these devices. Four had made or explored pictures showing motion, but they had not dealt with pictures showing motion in the plane versus motion out of the plane of the picture.

The majority decisions by the blind were as follows (table 8.3). Nine said that the radiating straight lines showed pain. Ten took the dashes to show numbness. Nine deemed the surrounding arcs as suggesting motion in a circle. Seven thought that the arcs across were for motion back and forth. On four occasions, across three of the devices, no referent was selected. For two
showed back-and-forth motion. It seems that the judgments of the blind are comparable to those of the blindfolded volunteers, and on the motion referents both groups depart from sighted subjects taking the test visually.

On the pain and numbness devices, the graphic additions to the outline form of the thumb are interpreted alike by the sighted and the blind. Investigation of this correspondence, however, is more difficult than is the case with depiction of relief edges in outline, and even more difficult than explanation of the use of graphic devices for motion. There is a clear set of physical rules for surfaces and motion. Although pain and numbness indicate physiological states, they are percepts whose description or phenomenology is obscure, and the physiological underpinnings are hardly better understood. As a result, whereas the explanation of a correspondence between a pictorial device and its referent in the case of surfaces is a projection from one set of physical features to another, with perception in the middle, in the case of pain or numbness the correspondence is between a pictorial device and a referent that cannot be readily measured, with perception of the device in the middle. At present, all one can do is attempt to clarify which features of the device seem most closely related to the referent, as far as the perceiver is concerned, and which features the referent has, again so far as the perceiver is concerned. In the long run, there is likely to be a theory of pain perception as mathematical as the theory of harmony, and it will be allied to a theory of painful stimuli as objective as the theory of physical vibration. At present, the referent for devices suggesting pain and numbness is a little-understood percept.

A device in a representation can be ambiguous. If so, there is no objective criterion favoring one judgment over another. At best, one can anticipate that one group's judgments can be predicted from another's—the blind by the sighted or the reverse. Just such a case is reported by Kennedy, Gabias, and Pierantoni (1990), who tested devices for showing motion. The pictures contained a circle described as a rolling ball. Behind the ball was a trail of arcs. One trail had dense, evenly spaced arcs; another had widely separated (sparse), evenly spaced arcs. In a third, the arcs were denser the closer they approached the ball. In the fourth, the arcs were more widely separated the closer they came to the ball.

Subjects were asked to judge which picture showed a ball going fast, which showed a ball going slowly, which showed a ball speeding-up, and which showed a ball slowing down. There are two modes of responding. In a "stroboscopic" mode, the wider the spacing, the faster the ball. In this judgment, spacing shows the distance traveled per unit time. In a "density" mode, the more closely packed the arcs, the faster the ball. Sighted subjects \((n = 176)\) responded chiefly in the density mode (55 percent) and about half as frequently in the stroboscopic mode (24 percent). The remaining subjects were inconsistent. Some (14 percent) gave a density judgment on the evenly spaced ball (the denser the faster) and a stroboscopic judgment on the decelerating ball (denser near the ball meant slower). A few (7 percent) offered the reverse—a stroboscopic judgment on the evenly spaced ball (the denser the slower) and a density judgment on the decelerating ball (widely spaced arcs near the ball meant that it was slowing down).

Kennedy, Gabias, and Pierantoni (1990) tested 14 blind subjects. Five had never used pictures. Six had made occasional use of raised-line pictures. Three had made frequent use of pictures. No one had used the device in question—a trail of arcs to indicate motion. Like the sighted, the blind favored a density response. Thirteen of the blind subjects were consistent: 10 consistently used density judgments and three used stroboscopic judgments. The inconsistent person gave a stroboscopic judgment to the evenly spaced stimuli but said that the dense arcs near the ball show acceleration. He mentioned that he "could make a real good case" for either kind of judgment: "If you take a picture—say the ball is here—and you take another picture, and it moved to there, you'd say 'wow, it moved that far!' [But also] you could say that the ball obviously has got twice as many marks here, so it could have traveled twice as fast. Like a fan blade, as it gets faster it kind of blurs together."

A repetition of the experiment by Gatti (1991), in an undergraduate thesis under Pierantoni's supervision, involved a large group of adult blind subjects, 86 in all. The results were very close to the responses from the sighted subjects. Consistent density judgments were made by 54 percent of the subjects and consistent stroboscopic judgments by 28 percent. Inconsistent judgments were 15 percent using density judgments for even displays and stroboscopic judgments for deceleration displays, and 3 percent stroboscopic for even and density for deceleration.

The judgments by the blind and the sighted are good news for any theory contending that the blind and the sighted have similar amodal perceptions of space and motion through space. But in any task where there are two logical alternatives, both having appropriate physical bases, there is no a priori way to predict how the blind and the sighted will behave. There is some deciding factor, but in the absence of any clear physical problem with one alternative, the rationale for a bias toward one alternative rather than another is elusive. There is some psychological factor at work, but what it is remains unclear.
DEPICTING A PROPERTY OF A SURFACE

Theories of expression and notions about art styles are in much the same quandaries as theories of pain or numbness perception. Emotion is as psychological as pain, and its physiological underpinning, like its basis in stimulus information, is not well understood. Gibson (1979) argues that the environment has physical affordances, offering physical comfort, threats to life and limb, succor, and privation. His ecological theory of psychological universals holds that these affordances are the basis for expression and emotion. Gestalt theory (Arneheim, 1974) considers expression to be based on formal properties of design and contends that these properties are not easily explained as affordances. Symmetry, balance, and proportion are formal properties that can make a display seem orderly, intended, and calm. To explain these effects as affordances, Gestaltists contend, is too vague to be useful. They suggest that perception has more degrees of freedom than the physical world of natural objects and their affordances. Convention theory holds that expression and emotion are a social construct. Its theorists propose that in a society with no established roles for anger, hope, or sadness, these emotions would not be felt, nor would displays be seen as expressing them. They also assert that devices for expressing emotions or affordances in representational displays are effective as a result of social rules, not universals of perception.

Research on expression is difficult because there is no clear physical theory of affordances, and it is doubly difficult since Gestalt theory and convention theory dispute the possibility of such a theory. Gestalt theory wishes to anchor expression in perception, and convention theory in social customs. The problems can be examined with a case in mind. Gabias and Kennedy (1984) studied a depiction of a property of a surface rather than an outline depiction of the edges of the surface. Figure 8.10 was shown to blind and sighted volunteers. The figure has a square crossed by wavy lines and a square crossed by zigzag lines. The volunteers were asked which picture showed a hard, unyielding surface and which showed a soft, yielding surface. The blind and the sighted agreed that the wavy lines suggested a soft surface and the zigzag lines a hard surface.

The simplicity of the study and the coherence of the results conceal theoretical puzzles. Why should waves suggest softness and zigzags hardness? Certainly the waves could be like fur or rolling hills and the zigzags like metallic blades or rocky Outcrops. Each of these suggest an ecology and appropriate hard or soft affordances. But it is easy to think of counterexamples. Rounded stones are hard; zigzag outlines of leaves are soft. Wavy patterns in marble are hard; zigzag tips of feathers are soft. Perhaps the basis for the comparisons between these static patterns lies in kinetic events. When something melts, it loses sharp edges. When it freezes again, it can acquire sharp angular forms like icicles. This explanation is post hoc and has little in the way of independent evidence to support it. The Gestalt theory that formal properties are used by the perceiver independent of an ecological referent has as much validity at present. Gestaltists note that some made-up words like takete are unfamiliar but possess abrupt changes, sound "hard," and are associated with angular forms with straight lines, whereas maluma sounds soft and is associated with rounded forms. These cross-sensory links, Gestaltists argue, occur without tutoring. Convention theorists could argue, too, that the adult perceiver may have heard that curves express softness and sharp angles express hardness, and that this is a social convention. Convention theorists note that takete and maluma are not readily connected with rounded and soft or angular and hard forms by some non-Western peoples (Kennedy, 1982a). It will take many converging lines of investigation to uncover the truth here, as cross-cultural and developmental evidence needs to be brought to bear. The enterprise can only be successful when an explicit theory of affordances is available so that one can show either that expression occurs independently of affordances but universally, as Gestalt theory has it, or independently of affordances but only after being taught a culture's customs, as convention theory asserts. At present, it seems that all three theses can explain some of the evidence, and the evidence is merely the agreement in judgments by various kinds of adults at some times but not others.
STYLE

Elizabeth Saltzhauer-Axel (1989), of the Whitney Museum in New York, teaches about art styles to the blind. She has tackled cave art and cubism, and she is creating allied programs on Egyptian art and the Renaissance. Her aims are complementary to the thesis of this book, and deserve to be compared and contrasted to the universals of perception and depiction described here.

Saltzhauer-Axel and her colleagues in Art Education for the Blind, a New York organization she founded in 1987, make tactile versions of celebrated works of art and explain them to the blind, accompanying their tuition with sound tapes. Marcel Duchamp's *Nude Descending a Staircase*, for example, has been simulated as a wooden statuette. The original painting has many heads, bodies, legs, and arms forming a single figure on a staircase looking rather like a Marey stroboscopic, multiple-image photograph of an angular but elegant robot descending stairs. Similarly, the statuette offers figures on a staircase, and the figures form a single mass with several legs, arms, bodies, and heads. Each part of the body is represented by pieces of wood, usually with a rectangular cross-section and a profile that has several straight edges and some shallow arcs. The effect of both the picture and the statuette is mechanical, and yet both represent a human body in continuous motion simultaneously at several phases of the motion. A living entity, a single body, and a continuous motion are shown by something that appears mechanical, multiple, and discontinuous. The statuette is accompanied in Saltzhauer-Axel's lesson by an auditory tape that reproduces the sounds of someone running up and down wooden stairs. The continuous rushing motion of the person on the stairs is signaled by a series of abrupt, brief footfalls. Once again, the continuous and the living are evoked by a sequence of discontinuous events. At the end of the tape the footsteps blend into a clacking mechanical sound fading away as though into the distance. It helps draw attention to the clockwork quality of the sounds of the feet on the wooden staircase. In addition, the repetitive clacks, like the footfalls, resemble echoes, multiple auditory images of a single event.

Saltzhauer-Axel's commentary points out that cubism, the style in the *Nude Descending*, was concerned with repetition, successive and simultaneous events, and the exploration of the effects of using multiple vantage points in making a single image. As Parsons (1987) pointed out in an examination of art styles and their comprehension, an art style is a series of elements and ways of combining them, and it is also a technique that is used at particular times for particular purposes. Cubism, for example, is a means for presenting bodies as sums of parts, often as geometrical parts such as rectangles, circles, cubes, cones, and ovoids. By reducing bodies, whether animate or inanimate, to sums of similar parts, cubism can be a tool for exploring the rather desperate intuition that life is no more than matter, no more than the sum of physical, electrical, and mechanical activities. In exploring the breakdown of the distinction between the living and the dead, cubism is also a tool for exploring opposites, like successive and simultaneous states, the whole and the broken. Cubism is visually exciting because it defies many standard distinctions. It shows in one moment what can only be seen across time or from several vantage points. It allows the viewer to try to see what is familiar in a radically new and often superficially violent guise, for things look as though they have been broken into many parts. *Nude Descending* allows the perceiver to try to make out the nude despite the transformations from single to multiple, from successive to simultaneous. Further, cubist representations make the perceiver wonder whether this picture could even be taken as realistic if the style became familiar enough. It makes one question the boundaries of perceptual learning.

Audiences of blind and sighted people react very favorably to Saltzhauer-Axel's statuettes, tapes, and discussions. The blind people I have observed in her audiences seem intrigued by her interpretations of particular pieces and by the idea that art styles are ways of exploring issues. They seem to be interested in the reproductions and to find the tapes valuable, not only in themselves as appealing sounds that catch the imagination, but also as vehicles by which to approach the reproductions. The audiences have been composed of adults so far, but I believe that this program holds promise for work with children.

Saltzhauer-Axel's sculptors and sound artists have to deploy considerable skill if their versions of aspects of an original work are to reproduce the target aspects effectively. A fragile version of *Nude Descending*--say, made of balsa wood--would betray the steely robot that comes down Duchamp's stairs quite elegantly. If the sound tape had creaky or slippery stairs, or the footfalls were hesitant or slithery, that would also violate the Duchamp's impression.

I believe that much thought could be put into devising sound tapes that have metaphoric qualities, in Saltzhauer-Axel's program. The footfalls on the stairs could be engineered to have reverberation, which might work well as an auditory analogue to the repetition in Duchamp's drawings of multiple legs. Sounds that are continuous like a sled on rough packed snow could be presented in staccato bursts to simulate the contrasts between simultaneous and successive. The multiple arms, legs, and heads of a single person could be evoked by a voice on tape that apparently says several phrases simultaneously. The analogy between an echo and a recording could be used
to emphasize differences between a natural repetition and a mechanical reproduction. Echoes, for example, always get quieter, whereas sound recordings can get louder on each repetition. Differences like this one could be used to draw attention to an event as mechanical, not natural, part of the study of the event and not the event itself.

Style has elements and combinational rules, but it also has meaning and purpose. Some styles probably lend themselves to delicacy and others to massive weight, suiting certain moods as well as challenging everyday perception. Some uses of style, it seems, can readily be applied to evoke contradictions, ironies, hyperbole, and litotes (Kennedy, 1982a). Abstract ideas about value and human significance on the scale of the universe or history can be embodied in particular works. The vantage point chosen can suggest that we are comparatively small or elevated (Kubovy, 1986; Kennedy, 1988c). Further, the embodiment reminds one of the occasion in which it was made and its place—whether derivative or original—in the traffic of its time. Duchamp's painting has a good deal to do with the influence of multiple-image still photography and the study of motion in early twentieth-century France. Cave art reveals the flora and fauna of its age and gives rise to unanswered questions about the culture that originally surrounded it. Convention theorists point out correctly that Duchamp's purposes cannot be read unambiguously from the appearance of the work, and the more that is known about the era, the better the piece can be recognized.

A cautionary note is sounded by deconstructionists, who emphasize our limits in establishing the visual impression the work was designed to create for its contemporaries. They note that the limits to our appreciation that are so blatantly obvious when it comes to cave art are still in force when we try to recapture any meaning or intended impression even of a recent work. What is undoubtedly true is that education adds considerably to the reaction that a depiction can reliably instigate, and many aspects of style will go unnoticed, or remain as unresolved ambiguities, without a program of instruction such as Saltzhauer-Axel's.

In principle, if an art style lends itself to a certain purpose for the sighted, it can also serve that purpose for the blind. A good guide can enable the blind or sighted person to envisage that purpose and to test whether the style and a particular graphic work fits it. Without the guide, finding the relevant purpose to consider would be almost an impossible task—the purposes to which a picture can be put are too many. Depictions have served quite serious purposes, communicating about matters as profound as religion, politics, science, and economics, so it is worth the effort to build on what is natively endowed, universally, and to explore the cultural settings of pictures. There is also reward in pictures in a lighter vein that act as pastimes in comic strips. Pictures can be humorous, quizzical, even at times bizarre illustrations of the day's mores and imagination. They can allow us, as Parsons (1987) points out, to discover the limits of our perception, to find out individually what our own perception can and cannot do, where in matters of motivation we have become jaded, unfortunately, and where our appetites are still fresh.

Parsons's reminder of the powers and limits of perception is a valuable part of the theme of this chapter: the boundaries of what can reasonably be expected of perception and of pictures given the evidence about universals and perceptual effects from quarters such as the blind. In this chapter I have argued that there are universals of perception and representation, and that it is important to determine what can be built from the universal elements and what rules are spontaneously followed by those who have not been taught them. Pictures can have a style, but many of the more profound uses of style should be described along with the illustration, for they will escape the casual perceiver, blind or sighted. At the same time styles, like the basic elements of depiction, can surely suit their intended referents, and if so the fit should be equally apparent to the blind and the sighted.