During two interviews with me in New York, Tracy, age 28, totally blind since 24 months, produced several drawings of a cube, folded cards, and familiar objects. Her first drawing of a cube at my request was a square with four arcs, one in each of the comers. Figure 5.1 includes that drawing as well as one of Tracy's later drawings of a cube, made in her second interview with me and showing two well-executed rectangles joined along one side. These stand for the two sides of the cube that face the observer. They are joined by a decidedly puzzling line that curves across the top. It is not immediately obvious what Tracy means by this line or by the arcs in her first drawing.

A study of drawings of cubes by sighted children and adults, however, might reveal that Tracy's drawings fit into the kind of drawing development we see in many sighted children. Perhaps sighted children produce the same kind of drawings as Tracy's at certain ages. Warren (1984) and Hollins (1989) remark that drawings by the blind are extraordinarily varied. Arnheim (1974) notes a good deal of variation in the sighted. It is important to check whether the range of variation of the blind is within the bounds of variation found in the sighted. I shall delve into comparisons of drawing ability in sighted and blind children, attending especially to Tracy's cubes and other drawings to see where they might fit.

The general supposition behind this examination of Tracy's work is that there may be a close correspondence between drawing development in the blind and the sighted. Given a system of drawing used by a blind person, it
blind children. It is generally expected that as they mature sighted children will come to show more advanced drawing skills, slowly acquiring principles of increasing sophistication. Perhaps the same is true for blind children even though they have had very little exposure to pictures. Indeed, it may be that much the same course is followed by blind and sighted children, though most of the blind children may not progress at the same rate as most of the sighted. In this chapter I shall consider how drawing skill develops in sighted and unsighted children. I shall present the results of one extensive study of sighted children, ages 4-15, and hazard a few guesses about what stages of development preceded those evident in four-year-olds. My plan is to consider the development of drawing in the sighted child and then to look for the main principles in drawings by blind children.

There are many factors influencing drawing and its development. The crucial ones here are those that apply most widely to the representation of objects, and I shall try to avoid factors with too narrow a range. Sketches can, of course, be made for restricted purposes, for example, with the aesthetic aim of decoration rather than the aim of representing particular objects. Kellogg (1969, p. 26) argues that a great deal of child art has little to do with communication from artist to viewer but is a matter of esthetics and pleasure. As a result, some of the principles being brought to bear on drawing are at times applicable only to certain subjects; they follow from the desire to achieve a certain effect. Likewise, in drawings by adults some devices are restricted to a certain art style, convention of symbolic communication, or type of object. In many cases, children learn to copy rigidly invariant prototypes of objects. A prototype is a drawing with a fixed pattern repeatable at will. One prototype that was widespread for a time (in the late nineteenth and early twentieth centuries) but has now almost vanished was a two-eye profile (a profile inside a circle, with two eyes) for the human face, and another was a mouth drawn like a ladder (Wilson and Wilson, 1982a, 1982b). Prototypes are common in sighted children's drawings, even though particular prototypes such as Snoopy are only widespread for a time. The medium in which the representation is made may also influence the child, as in making faces on a plate at dinner time with sausages for a mouth, a bacon-strip nose, and potatoes for eyes or--a more demanding task--making a snake from irregular straight strips in the basket weaving (Arnheim, 1974; Golomb, 1990). Many of these influences on drawing development create skills that are comparatively isolated from each other and from the rest of psychological functioning. The result is a vocabulary of independent schemas alongside a general procedure for picking up the schemas (Wilson, 1985; van Sommers, 1984, p. 161-64). Learning the ladder-mouth schema probably has little effect.

**Fig. 5.1. Drawings by Tracy (early, totally blind) of a dog, a horse, a cat, a man, and cubes.**

may be possible to identify an age at which a sighted child would use that same system.

**DRAWING DEVELOPMENT THEORY**

The first drawings of a sighted child 2-3 years of age bear fairly little resemblance to their referent. The same can surely be said for those of many
on drawing other subjects, such as an elephant's body. The fact that the schemas are independent of each other is reflected in such children's comments as "I don't know how to draw a giraffe" or such requests as "How do you draw an ear?" Each object is treated as a referent requiring its own pictorial formula. If the influences on a child's growth are like tributaries joining a river, these schema are like oxbow lakes thrown out by the main course of development without contributing much to the general flow. Psychological development is likely full of oxbows, directions useful for a time but cut off once a more direct and powerful route is found. It is a common observation that cognition allows room for remembering isolated items of trivial knowledge, although it is the general principles in each of the major domains of knowledge that are the engine of intellectual growth. It is these intellectual principles that I wish to identify in drawing development in the child.

Drawings made by the sighted seem to be governed by general principles as well as a mammoth dictionary of schemas. The general principles concern the nature of representation, restrictions on the use of an element, and configuration rules for arranging elements.

The nature of representation is mat one item can stand for another in the sense that A represents B because A is intended to make someone think of B without there being any other intrinsic connection to B. The intention is known to the user of A and the receiver of A, if the intention succeeds. Propositions using A are about B. Showing A can be done to show B.

The restrictions on the use of an element in outline drawing are concerned with using the line to stand for features of objects, primarily features that the line evokes in perception and not just in cognition. In a picture the line does not stand for items chosen solely because a person has designated the line as a representation, establishing a convention. Nor has the line been allowed to represent items chosen on the basis of convenience or rules that are invented anew for each drawing. Rather, the line creates an impression of the designated feature. Presumably it does so chiefly because of functions in the perceptual pathways that treat lines as surrogates for features of relief.

Configuration rules are matters of projection. They relate the locations of lines in the picture to locations of parts of the object. They indicate how two lines can be adjoined as well as how they are shaped individually, and how long they may be in relation to other lines. These rules can include matters of perspective convergence and how to set the picture surface between the object and the vantage point. If one line in a picture representing a certain kind of scene is short and straight and represents something long and straight in the referent, this sets restrictions on the locations and lengths of the other lines in accordance with the configuration rules.

It should be immediately apparent that there is a direct conflict among the 'major principles defining pictorial representation. In its most general form, representation involves A standing for B and is achieved because of an intention to affect another person's thought, but without any intrinsic connections between A and B. Pictorial representation, by contrast, requires mat A allow perceptual impressions of B in key respects. The conflict between these requirements results in the bipolar development of drawing in the child, one pole emphasizing representation without perceptual fidelity to the referent and the other insisting on representational criteria mat adhere to perceptual impressions.

The fact that representation can rest on what is meant rather than on forms that unmistakably specify or resemble their referent is vital to many kinds of pictures—for example, rough sketches. It enables pictures to be understood while showing only a few aspects of the referent. That is, for a depiction to give appropriate perceptual impressions, it is not necessary for it to represent so many aspects that the species of the object, or the individual object, is unambiguous. The picture may show only a few relevant features and the object can be asserted to be represented. Even in the absence of specificity the few relevant features can give rise to the appropriate impressions in perception provided the features fit with the lines (or other elements) making up the picture. The assertion helps the perceiver decide what is relevant, and if the proper elements are present, aspects of the referent can be seen. On the other hand, the fact that perceptual impressions are used in pictures means that a detailed, unambiguous picture is likely to be seen as a faithful rendition of the referent by any observer, with no hints or training, provided the observer can recognize the real referent in the first place.

Developmental theories of outline drawing have to address the role of the line element stimulating perception, the configuration in which the element is placed, and the person designating the element as a representation. At one extreme, a theory could entail a combination of inadvertent actions and accidental specificity. It is conceivable, for example, that the child makes marks as an accidental accompaniment to motor activity. At some point the marks could become sufficiently complex that inadvertently they have a form specifying a category of objects in the environment known to the child, with enough distinctive features to single out that category rather than any of the others known to the child. The child might then be so impressed by the discovery of a recognizable, specified object that he or she sets out to repeat the form. After several attempts, the form becomes a pattern the child can execute reliably. Accidental discoveries are made repeatedly by the child, and in time mastery of a dictionary of schemas develops. Some of the schemas are
copied deliberately from the pictures made by other people, especially other children. With time, the child invents more abstract principles, including aspects of perspective such as convergence. The child eventually becomes free of the need for recognizable objects and can draw unfamiliar arrangements of features of surface layout. Later the child's drawings may eventually become free of the need for specificity and become more abstract. The child can then draw a few lines and allow them to stand for a feature of layout in isolation without needing to rely on a great deal of context in the picture. At this juncture the intent to depict is finally enough support for the few lines to work well in perception. In this theory, drawing a picture is initially inadvertent. Children need a great deal of detail in the early stages of development of drawing; only later can they work with displays that are mere hints.

There is considerable merit to this account of drawing development. Children do enjoy motor activity, make accidental discoveries, learn schemas, and in some respects gradually become more abstract. It is not the whole story, however. In many cases, children begin with abstractions and gradually find concrete matter to which the abstractions can apply. An opposite, alternative theory is probably closer to the truth. The infant can intend to make a representational display, selecting what is relevant from the referent and putting marks on the display that stand only for the aspects that were selected. Specificity is not an issue for the young child who is drawing, since it is achieved by the will to represent and not by detail in the display. Only some aspects of the marks are relevant, and the child selects the aspects that matter (such as the number of objects or the length or form of a single object). Resemblance of shape is initially very general or highly abstract; only later is it a matter of proportions of curved and straight components of the line matching relief features and evoking impressions of relief. The ability to accept that a mark represents a referent even though it does not copy its form in detail, accurately, or evoke impressions of relief is never lost to the normal perceiver, and it surfaces in various different guises in development.

Let us consider some evidence about these rival theories of drawing development, one stressing unintended actions, the other stressing intentional representations. Lowenfeld and Brittain (1970) argued that the initial interest of the child in making displays was motoric. The child's motivation is in the movements, not in the graphic effects on the display surface, they suggested. Any marks that could be perceived as representations were thought to be inadvertent. Two studies undermine this suggestion.

Edward Mueller and I observed five 14-16-month-old sighted infants engaged in finger painting. The children were part of a play group that had met one morning previously. The finger-painting activity was a new option for these children. A coffee table was covered with white paper, and black paint was added in patches to the paper by an adult supervisor. The children approached the table slowly, inspecting the surface. For all five children, contact with the paint was initially limited—for example, they might examine it with fingertips, touching it only lightly, while looking at the paint. Motion of the hand was slight at first; only later were there lengthy pulling motions of the fingertips through the paint, toward the body, or pushing motions away from the body. Fingertip contact generally preceded palm contact. One hand was generally used before both hands, and a part of the hand before any other part of the limbs. Single motions (one push or pull) preceded combinations of motions (push-pull cycles). Vision was an important part of the infant's initial contacts, which were made while gazing in the direction of the contact, and only later would motions be made with the gaze off to the side. Here is a record of the initial 19 contacts of one of the children. The record is based on a slow-motion videotape of the events. "Gaze on" means: the child was looking in the direction of the paint being contacted.

Robert finger painting
1. Two fingers, right hand, 1 pull. Gaze on.
2. Heel of left hand, 1 touch. Gaze off.
3. One finger, right hand, 1 pull. Gaze on.
4. Several fingertips (number unclear), right hand, 1 touch. Gaze on.
5. Four fingers, left hand, 1 slap. Gaze on.
8. One finger, right hand, 1 pull. Gaze on
9. Four fingers, right hand, 1 pull. Gaze on.
10. Four fingers, left hand, 2 push-pulls. Gaze on for the initial action, and off for the remainder.
12. Whole left hand, 4 push-pulls. Gaze on.
13. Several fingers, right hand, 1 slap-pull. Gaze on.
14. Whole right hand, 4 push-pulls. Gaze on.
15. Whole right hand, 1 push-pull. Gaze on.
16. One finger, right hand, 1 pull, then 1 push-pull, then, in a continuous action, whole right hand 1 pull, then 1 push-pull. Gaze on. (Robert leaves the table briefly.)
17. Both hands fingertips, 1 touch. Gaze on. (Robert leaves the table briefly.)
18. Both hands, 1 slap-pull. Gaze on.
19. Both hands: left hand 1 finger 2 push-pulls, right hand all fingers 1 touch. Gaze off. (Robert leaves the table.)
Robert's record reveals delicate contacts preceding larger contacts, rather than precise restricted contacts emerging from undifferentiated global activity. The number of actions in a continuous sequence increases over time. The units of behavior expand to include more actions, larger motions, greater involvement of large muscles of the body. Gaze on precedes gaze off. The motions are not initially random gross actions eventually leading to refined brief touches. Gaze off likely indicates lack of interest—or interest caught elsewhere—rather than initially unfocused attention, which only later becomes precise. The child likely was engaged in exploration that included perception in the form of careful observation of the effects of motion. The initial actions were probably not undertaken primarily to enjoy bodily motion, as Lowenfeld and Brittain conjectured. The record suggests that the initial explorations by the child involved intense attention to each judicious, brief, tentative contact, and possibly to any effects of the manipulation.

The need for the effects of drawing actions to be observed by 14-16-month-olds is underscored in a study by Gibson and Yonas (1968), with slightly older children (ages eighteen months to three years). The children were given two kinds of markers. One left no clearly visible traces; the other did leave a visible track. Both contained fluid, and they were similar in all respects except for the visible stains left by one. If the child's scribbling behavior was largely motivated by motor consequences, then both markers should have been equally satisfactory. The result, however, was that the children quickly stopped using any marker that left no visible traces and sought the other. Scribbling was more prolonged with the markers that made visible tracks.

Lowenfeld and Brittain are no doubt in error in stressing the motor action to the exclusion of the close visual monitoring accompanying the action, and in implying that the body motions are the basis of finger painting or scribbling rather than the perceptible effects left on the display. Children understand full well that they can make marks. These are not accidents on the periphery of attention: they are deliberate. If so, they can be given an explicit role in communication. They are available to intention and can be subject to the will to represent. Since children see marks as deliberate, they have a basis on which to use a mark as an object intended to make a person think of another object, making the intention known to the other person.

A relation between picturing, announcing, and action is noted by Golomb (1990) and Wolf (1983). Wolf found that children at age two frequently announce that they are making marks concerned with some object that is related to their action. The children mention a rabbit while making their marker jump from one part of the page to another, leaving prints at each impact. Or the marker may circle around the page and the child may say something about a car while creating suitable sound effects. The marker leaves circles on the page, it should be noted, and does not just move leaving the page undisturbed. I have observed children making one mark for one person, with a few features of a person, another mark with fewer features for another person, and many more quite nondescript marks for a crowd of people, with an announcement of the person or the crowd being made as the action is undertaken (Kennedy, 1974b). My own observations and Wolfs suggest that children accept that a mark can mean something without having a shape that is related to the referent's shape. If so, the mark refers because it is subject to the desire to represent something. It may not be necessary that there be an action related intrinsically to the referent. In this case the mark is beholden to an act of will; that is, the child draws by fiat.

Drawings discussed by Wolf are a useful case in point. Wolf (1983), like Golomb (1981), studied two-year-olds making drawings under two conditions of supervision. In one, the children drew freely without suggestions, and in the other the children drew while items were suggested to them. Children ages two years four months and two years six months drew shapes that bore no obvious similarity to the object being drawn: houses were elongated squiggles, legs were large dots, and arms were large circles or spirals. Eyes were squiggles placed one above the other. One child drew the head as a small mark between the eyes. Thus each item being shown had its own representational mark, but the mark bore no affinity of form to the referent. In Golomb's words, "forms are utilized, but they are subordinated to the demands of the task i.e. to the meaning of the figure" (Golomb, 1981, p. 39). The marks refer by act of will Golomb and Wolf, however, also noted that if two-year-old children drew parts of the body following suggestions, they could distribute marks along a spatial dimension with representational intent. When parts were explicitly suggested by a tester, children placed the mark standing for the head above the body, the body above the legs, and the legs above the feet. Thus the extendedness of an object could be shown implicitly, even where no mark bore the shape of the referent (Golomb, 1990).

As Strommen (1988) points out in a review of drawing development research, several recent theorists, notably Freeman (1980) and van Sommers (1984), closely examine specific devices children use. Freeman gives an account of a young child thinking of the features to show in a drawing and the order in which to show them. He suggests that much of drawing development can be explained as the ability to produce, first, pairs of right angles, later a pair of oblique angles, and finally one oblique and one obtuse angle. What encourages children to select these solutions to drawing problems? Some
Drawing Development

Theorists give accounts of the amount of information the child can attend to and use to guide drawing, but I wish to stress the basic perceptual and cognitive spatial principles children apply rather than the number of principles or devices they use. Freeman points out that children may think of a "first" feature or main feature like ahead and a "last" or ending feature like a leg and omit the rest. Often, the form is oriented on the page vertically, and the legs are connected to the head as parallel lines, producing a "tadpole" man with an appropriate spatial dimension (the feet away from the head). Wolf and Golomb found that when an adult supplies the list of features and thus frees the child of the need to think them up, the child supplies an appropriate spatial dimension for a large set of body features. The marks were distributed spatially, even though none of the marks was spatially similar to its referent. The key principle is the child's Use of a basic spatial dimension, although the number of features depicted by the child may depend on the amount of support and instruction that is given.

It is a short step to the stage when children make spatial properties of many features of the object evident in the drawing on their own initiative. This stage may be typical of three-year-old sighted children. Golomb (1981) found that 80 percent of three-year-olds make "pictorials" (Kellogg, 1969) of this kind. John Willats (1989) has observed, "In drawings by very young children extendedness may be the only property to be represented: typically, lumps are represented by round regions, sticks by long regions or lines and heads by dots," Such preschool children, Willats asserts, attend to three basic shapes: "lumps" for objects like balls, heads, or houses which extend fairly equally in three dimensions; "slabs" for objects like books which extend more in two dimensions than in three; and "sticks" for objects that extend mostly in one dimension. If extended in one dimension, a region on the page looks like a stick; if extended in two dimensions, it looks like a lump. It is hard to invoke a slab perceptually using a system that only controls extension on the page as lines (one dimension) or rounded forms (two dimensions) and not as contour. A cube drawn in this system, as by 3-4-year-olds, becomes a rounded region. Of course, regions standing for whole objects could use some shape features of the regions. Moore (1986) noted that when children ages 5-7 draw a cube with colored faces, they may draw a roughly square region and then put all the colors in separate patches within the region. Thus, the square region stands for the whole cube and all of its faces. Similarly, Willats noted that children ages 5-7 drawing dice would draw an enclosed region and then put all the dots from all the faces inside the region. In employing extendedness, children use the shapes of the marks they make, with some similarity between the mark's shape and the referent's shape. Extendedness may be just one part of a geometry of similarity employed by the child. Some other notions of similarity of shape must be important, I think, even to very young children, because a child of three is surely able to draw a crescent moon as a C shape and a wiggly snake with S shapes. If extendedness were the only salient feature, the child could only draw a crescent as a circle and a snake as a straight line. My informal observations are that drawings by children ages three and four who draw cubes as circular regions often display a mixture of shape dissimilarity and shape similarity. Not only do wiggly lines show snakes with many curves; the lines are often oriented vertically or horizontally on the page to show the orientation of the object. I suggest that children do not draw just the main extension of many highly curved objects. If a gently curved horn is depicted as an arc, not a straight line, clearly children notice the axis of the form. If three-year-old children are attending to axes of forms, their extendedness is part of an articulate geometry of shape including straightness and curvature in some of the earliest pictures made by children.

If the child emphasizes shape properties such as extendedness, then the outline form on the page can match the silhouette of the object, as a square can depict a cube, without actually referring to the silhouette. The outline form often stands for the whole object. Willats points out that die line on the page marks the boundary of the region on the page, and the region on the page may be what is relevant to the child. Initially the child may not treat the line as a device for showing occluding boundaries or convex corners of the referent. That is, the notion of relief perceived from a vantage point is not being used. Since occlusion and corners are not singled out as the basis for outline, the child is free to think that the line and what it encloses may be able to depict a number of aspects of the form being pictured. The line can indicate length, for example. If the width of the region between lines may stand for the width of an object without the child realizing that the lines betoken the edges of the object. In children's sketches I have noticed drawings with two lines crossing (forming an X) to show a quadrilateral face (by diagonals) or a cone (by parts leading up to the apex) as illustrated in Heller and Kennedy (1990). A telling Comment from Willats is that to show a sharp edge or comer, the child may need to add a line alongside the outline form. Willats observed one child who drew three lines: where one would be sufficient: one was a boundary of the region showing the left face of a comer, a second was for the boundary of the right face, and a third was for the corner itself. Let us call this a three-line corner. Katz (1946, fig. 14g) made a similar observation.

When shapes of the parts of an object are first being drawn, the child may show each part by a separate mark on the page, neglecting the overall shape of the object itself. In Wolf's study, sighted two-year-olds drew individual parts
without an overall silhouette, and each one was often distributed without regard to the others. The parts were "listed" in the order they come to mind, one might say. Often apart was repeated. Caron-Pargue (1979, p. 156; 1985, p. 56) discovered that sighted 4-6-year-olds would draw a cube with closed quadrilateral or roughly circular forms. Though each form might stand for a side of the cube, the number of forms varied from one to more than a dozen. (I have never observed a case like this among the blind, but I have never tested blind four-year-olds.) The forms were often distributed quite widely and irregularly over the page, sometimes with them overlapping and sometimes with each form distinct. Sometimes two forms shared a side or several sides. In all these cases the distribution of forms ignored the extendedness of the object, and in all cases the connections between some of the sides were disregarded. What mattered to the child was that square shapes were relevant to faces of the object, and the number was unspecified.

An important step in drawing development is when the child insists on making the connections between parts evident. To show the connections correctly, their number has to be correct, and that helps keep the number of facets correct. It also means that the lines mark the occlusions and edges where connections between facets occur. An important ambiguity becomes resolved when children first begin to use lines as edges rather than as boundaries of regions on the page. A three-dimensional "slab," in Willats's terms, cannot be shown perceptually by a two-dimensional region on the picture surface; the region tends to look like a lump extending fairly evenly in three dimensions. To show a slab, such as a book or a chocolate bar, the boundary of the region has to be depicted. The details of the boundary can be used reliably by vision to obtain a vivid percept of a slab, as shown in figure 5.2.

Concentrating on edges of objects and the line around a region on the page involves drawing initially one facet of the object, with each line depicting its edges. The shape on the page is geometrically similar to the facet's shape. This initial step may be sufficient to draw the object for many children (say, for five-year-olds). Other children, however, may try to add more facets, one after another, to the drawing. Various Strategies for adding facets may dominate the drawing development of school-age children. The first facet chosen is likely to be drawn completely, and others may be less complete if to draw them completely would make them cross the lines of the first. Goodnow (1977) notes that children ages 5-9 often avoid such crossings even when they are appropriate. The effect is noticeable in drawing curved objects, such as a cylinder, where a rectangle can show the cylinder's extendedness in two dimensions but circles are needed for the third. Drawing complete circles at the top and bottom would involve lines cutting into the interior of the rectangle. Often the rectangle is drawn completely, but the child may merely draw half-circles for the top and bottom to avoid lines crossing each other. Caron-Pargue describes the part shown completely as "emphasized." Conversely, one side of a straight-sided figure may be drawn curved to show how it connects to another part. Katz (1946, figs. 14i, 14k, and 16d) reproduces drawings of cylinders by blind students with one or another part emphasized and no crossing lines.

Arnheim (1974) described the selection of a square for a cube and a rectangle for a cylinder as a "logical" analysis of the referent. These forms copy a basic distinctive part of the shape of the object. Arnheim noted that the added facets help to distinguish the referent, singling it out from the growing number of alternatives the child bears in mind as development proceeds. The circles added to a rectangle, in drawing a cylinder, show that the rectangle is part of a rounded form, not a slab. The progressive addition of facets can be described as drawing the object as though it were "folded out," a procedure that retains connections between parts but fails to maintain the angles between connecting parts. Katz (figs. 15c, 15d, 15e, and 17e) noted fold-out versions of a pyramid, a cylinder, a cube, and a prism.

Various fold-out drawings seem to occupy the sighted child asked to draw cubes and cylinders from the ages of six to about nine. Although the child draws facets with appropriate connections, it appears likely that connections are part of a more general class of features the child aims to depict (Golomb, 1990). Other features include enclosure as opposed to being alongside or behind. Goodnow's observations suggest that any lines meeting or crossing on the page are taken by the child to denote parts of the referent that are
physically connected. In this vein, Piaget and Inhelder (1956) described the child as using topology, the geometry of connections. Topology, often called "rubber-sheet" mathematics, is the study of places that join other places, like knots, and barriers between places, like mazes. In topology, a flat ribbon is one connected surface, as is a circular plate or a crescent moon. These shapes, however, are surely treated as quite distinct by 6-9-year-olds (and probably so by 3-4-year-olds). Anders are one connecting surface, but they will be drawn by branching lines, not circles. Thus pure topology is too general to describe the child's foldout drawings. Topological relations are important, but surely they are an addition to the earlier geometries using extension and similarity of shapes.

The foldout style of drawing has definite disadvantages. If an object has a large number of facets, drawing them leads to a confusing arrangement of a large number of forms on the page. The silhouette of the object is quickly obscured so that it is unclear what is a corner and what is an occlusion. The drawing is ambiguous about what is to the front and what recedes in depth to the side. It is impossible to draw all the connections without repeating a facet. While the meeting of the front with the top and the sides can be shown, it is impossible to show how the top and sides meet without distorting the shapes of the facets or drawing lines whose sole function is to link the facets. Children using the foldout style frequently comment that they had to add a line just for the purpose of connecting otherwise isolated parts of the drawing. Without the connecting lines there would be nothing to show that the parts adjoin in the referent.

There is no solution to the contradictory demands set by the foldout style. Probably as a result of this, at about 7-10 years of age children shift their aims, adopting a new criterion. They devise rules that derive from a geometry involving obliques and perspective, Willats and Caron-Pargue argue, corroborating Luquet (1927). These can, I think, be described as arising as ideas about the effects of a vantage point. The rules governing vantage points are a considerable source of debate in drawing development theory (Golomb, 1990). Among the possible rules a child might devise is that only the front and top should be shown, or oblique lines should indicate a side receding into depth (Arneheim, 1974), or convergence should indicate parallel sides receding into depth. For vantage point geometry, the key idea is that only those aspects of the object simultaneously facing in a single direction need to be drawn. Whereas the foldout system uses the shapes of facets copied by similar forms on the picture surface as its basis, the vantage point systems are concerned with the direction of the facets of the object from a point. In its simplest form the parts of the object facing a given direction are shown, with each facet being copied as in the foldout style, but in its sophisticated form the vantage point can be chosen at a well-defined spot at a given distance from the object. To use the sophisticated version one must recognize that the picture surface intervenes between the vantage point and the referent. Further, the surface can be placed at a particular slant between the object and the vantage point. Slight changes in the surface slant can produce all the effects sometimes attributed (as, by Lee and Bremner, 1987) to change in the height of the vantage point. In the initial, developmentally earliest form, if the picture surface is ever considered explicitly, it is taken to be parallel to a major facet or axis of the object, and usually the orientation of the picture surface is vertical. In its sophisticated form, the picture surface can be placed at any convenient slant along the range from horizontal to vertical, whatever the orientation of the object may be. Given a sophisticated geometry, the direction of any point on the object from the vantage point can be established. Where the direction intersects the picture surface, the picture has a point representing the point on the object. Important theorems apparently first discovered by Filippo Brunelleschi in Renaissance Florence apply (Kubovy, 1986, p. 31), such as that the distance from the vantage point to the foot of the normal from the vantage point to the picture plane is the same as the distance from the foot to the vanishing points of parallel edges at 450 to the picture plane.

Sighted children generally do not offer formal theorems about their vantage point geometries, and there is controversy about the rules they follow. Certainly, most sighted children do not have sophisticated procedures for calculating exact angles at junctions and sizes of lines when they make drawings. Rather, they have an informal sense of proportion and general rules such as "Things in the distance are represented by progressively smaller angles" and "The picture surface is parallel to the main body of the object." As a result, the typical vantage point geometry evident in many children's drawings is intermediate between the simple and the sophisticated versions, and it is not clear how children progress beyond foldout principles through simple perspective toward the sophisticated version. The most general principle that researchers are likely to agree on is rather vague. It is the claim that sighted children at ages 8-12 draw following informal rules, checking their product by eye. If they correct their drawings, they do so by visual estimation of the correct proportions and angles, not by calculation.

Children who know that an object subtends a smaller and smaller angle as it moves away usually do not know how much smaller exactly. Often the more advanced children, say 11-13-year-olds, make some use of a horizon as a locus for vanishing points, but they do not calculate the correct vanishing points (Lee and Bremner, 1987). Except in rare cases they certainly do not...
know Brunelleschi's formal rules for checking their drawings. Many children with an informal geometry of perspective will draw the side faces of cubes with parallel or converging lines without a clear understanding of when to use parallels and when to use converging lines. They will make the front face square, and the side face will almost invariably be given lines that are shorter than those of the front (about two-thirds the size of the front, Nicholls and Kennedy [1991] find). Notice that virtually no child will deliberately make the side face's lines much longer than those for the front. Their informal geometry fails to predict when the side face projects a much larger area than the front face on the picture surface. They make visual checks with both eyes and a moving head rather than monocularly from a fixed distance and at a fixed angle to the display. If they look at a drawing with a side face larger than the front face from a point directly in front of the drawing, their vision will reject it as a possible drawing of a cube (erroneously, as Pirenne's [1970] pinhole camera photographs show). The result is a geometry that departs wildly from proper single vantage point perspective.

I think it is reasonable to propose that 8-12-year-olds have a set of procedures or ordered actions present in their rules for making a drawing of an object (Freeman, 1980; van Sommers, 1984) as well as, somewhat independently, a procedure for checking the drawing at various stages of completion. A child may know that some drawings in perspective look erroneous at first, then fall into place as more details are added, the projection system becomes unambiguous, and the vantage point becomes evident. Perhaps from 8 to 12 years of age more and more drawing procedures using perspective become incorporated, and more and more projection principles become engaged in the inspections. But I think it is safe to say the criteria being used in the inspections are initially lax.

Even in adult observers familiar with perspective pictures, vision is not a perfect judge of polar perspective, in at least three respects. First, drawings of a cube or a landscape in parallel perspective are acceptable to vision. Freeman (1980) and others note that this tolerance of parallels is common in children and adults despite the fact that light converges to the visual vantage point. Parallel projection is incorrect, strictly speaking. It is probably tolerated by vision so long as its results approximate polar perspective effects. Second, drawings of a scene subtending less than a wide-angle view (less than about 30°) look appropriate even when viewed from the wrong vantage point (Kubovy, 1986; Johannson and Botjesson, 1989). The tolerance for an incorrect vantage point is much greater for flat-surfaced or cubic objects (up to 30-35°) than for rounded objects such as spheres (where the limits are often under 2°). The tolerance for an incorrect vantage point has well-defined limits even for cubic objects. In photographs taken of a scene subtending beyond 30-35°, cubic objects appear distorted in angle or proportion, or in both when viewed subtending a smaller angle (20° or less). Third, a scene can be drawn using different vantage points for different parts of the scene without vision recognizing that more than one was used (Kubovy, 1986, p. 117). All three findings indicate that vision uses lax criteria. (There is a fourth finding about perspective that may be explained by this laxity, but no one is yet sure. Spheres viewed off in the margins of a large picture such as a mural can be drawn as circles when strictly they should be drawn as ellipses.)

The vantage point geometry used by children to evaluate a picture contains profound principles, but likely it embraces only a few rules at first. Vision probably never follows all the rules of exact perspective without formal training. The rules vision follows could be matters of angle and proportion. Perkins (1972), for example, demonstrated that vision accepts projections of corners of cubes in drawings when they are in keeping with the angles projected by real cubes. The Perkins angle law probably has a sibling proportion law. I suspect that vision rejects side faces of cubes in drawings if vision can detect that the quadrilateral in the drawing representing the side face is larger than a square representing the front face. Vision prefers a proportion of about 0.6 for the side face if the front face is a unit square. These rules are imperfect versions of accurate perspective. Nevertheless, this is a geometry that lends itself to visual inspection of a drawing.

The more inspection comes to the fore, the more drawing becomes subject to an intuitive set of criteria whose profound central principle is direction from a vantage point. The criteria are in perception, not will. Vantage point criteria are in keeping with perception from a fixed point, so they apply perfectly to perception of a static picture. Essentially for the first time in development of drawing this makes it possible for the typical child to find drawing a difficult task in which to meet criteria for acceptability. The child is able to sense that his own drawing fails in adequately representing the object, and rejects it according to criteria that, being perceptual, lie outside of the act of drawing and the will to represent. Luquet (1927) called this stage "visual realism," and observed that it required the representation of all the characteristics evident from a vantage point (Costall, 1991). But it would be better to note that the child is satisfying a vantage point geometry of vision that can become a taskmaster without being entirely accurate or realistic; one might call it "vision's perspective."

Vantage point geometry stresses what can be perceived at a given moment lying in certain directions from a point in space; hence it can establish some clear criteria about what cannot be shown. That which is occluded in the
referent cannot be shown in the picture. That which does not occur in a moment cannot be shown. These two criteria become allied with a sense of the limits of elements such as lines. That which is not evoked as an impression by the elements in the picture cannot be shown.

In a vantage point geometry emphasizing perceptual criteria, one of the novelties in the development of drawing is that for the first time many referents are deemed impossible to show. The child becomes aware of many parts of drawings that are violations of the rules given by the informal vantage point geometry and perception. Lines evoke spatial features—not sounds of cars, for example. Similarly; junctions become subject to perceptual matters. Y shaped line junctions that are acute or obtuse on the page but look rectangular when seen in depth are preferred over T junctions that are rectangular on the page but look flat, when cubic corners are to be shown.

**EVIDENCE FOR DRAWING DEVELOPMENT**

How do children acquire vantage point criteria for drawings? Willats argues that there are six necessary stages. Caron-Pargue offers a much greater variety of routes than Willats. She even finds children drawing the sides of cubes as triangles or rounded forms and depicting internal detail by X, Y, or T junctions. Lee and Bremner (1987) identify an early phase when children draw using similarity geometry and a later phase, covering a wide swath of ages, when perspective is represented by means of parallel obliques to show parallels receding into depth. Lee and Bremner suggest that drawing development is the acquisition of a series of local solutions, like parallel obliques, rather than a forced march through an invariant set of stages.

Are some stages much more important than others? To check on drawing development in the sighted and the emergence of vantage point criteria, Andrea Nicholls and I (Nicholls and Kennedy; 1992) examined drawings produced by children and adults. We based our analysis on types distinguished by Willats but also included some additional types, notably one taken from Caron-Pargue. Nicholls recruited volunteers at the Ontario Science Centre ranging in age from four years to adult (16-77 years, mean age 32). The volunteers were shown an opaque cube and asked to make their best drawing of it. For the children, we did not set the cube at a fixed location and stress its orientation, as we suspected that they might not be able to make what they deemed to be a "best" drawing under such conditions. Some drew the cube as though it were transparent or made of wires, like a Necker cube. These were set aside since we could not be sure whether they arose from a failure to understand the task or an inability to eliminate the lines representing the hidden sides of the cube. There remained 789 drawings by 4-15-year-olds (one per person) and 945 from adults (also one per person).

The classification scheme was as follows (fig. 5.3). Five categories were adopted from Willats. The first stage he called "pre-single aspect." The child shows a cube as a closed, roughly circular shape. The principle behind the drawing could be the attempt to replicate extendedness. The second stage is "single-aspect" drawing. A face of the object--here, one square--is shown, following a similarity geometry. Stage 3 is "foldout" drawing, which Willats calls "multiple aspect." Stage 4, "two square," is indicated by two faces shown attached, in which the horizontal or vertical is thought to represent depth. In stage 5, called "near oblique" or "Y and T junctions," a central vertex of the cube is shown by a Y junction and a vertex at the base by a T junction. We distinguished what Willats grouped as a sixth stage into four different kinds of drawings (categories 6-9), two based on parallel projection and two on polar projection. A "square with obliques" was a cube drawn as a frontal square and two sides shown by oblique parallel lines. A "vertex with obliques" was a cube drawn with a vertex or edge to the front, shown by a Y, the faces around it drawn with oblique parallel lines. Two other kinds of drawings were based on the "square with obliques" and the "vertex with obliques" but showed the sides with converging lines rather than parallel lines. A tenth type of drawing was based on a Caron-Pargue category that is not easily reduced to any of the Willat stages. Caron Pargue noted" dissection" drawings in which the cube is shown by a complete square ("emphasizing" the square aspect, in her terms) inscribed with diagonals, perhaps to denote that the overall object is divided into sections meeting at a vertex. A final category in the initial analysis was "other," meaning drawings that did not fit any of the 10 definite classes.

The sorting of the 1,734 examples was carried out by Carol Flynn. To check on the reliability of the procedure, another judge (Gordon Mack) assessed 25 examples drawn from Flynn's groups, with at least two examples of each category. The second categorization was performed without knowledge of the results of the first. Twenty-three of the drawings were categorized in the same manner by both judges, indicating that the scheme is reliable. The results of Flynn's categorization are presented in table 5.1.

In the children's drawings, the distribution is clearly far from random. Categories 6 (square with obliques), and 11 (other) account for 67 percent of the children's drawings. Together, categories 3 (foldout), 4 (two squares), and 5 (Y and T junctions) accounted for only 23 percent. Only 2 percent are dissection drawings (category 10). Convergent drawings (categories 8 and 9) occur only four times. There were only two category 1 (pre-single aspect) drawings.
TABLE 5.1
Number of subjects producing each drawing type at each age level. Percentages are in parentheses.

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<thead>
<tr>
<th>Age</th>
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<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>Obl Edge</th>
<th>Obl Edge</th>
<th>Diss</th>
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<td>(9)</td>
<td>(4)</td>
<td>(10)</td>
<td>(28)</td>
<td>(7)</td>
<td>(0.3)</td>
<td>(0.3)</td>
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<td>22</td>
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<td>64</td>
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<tr>
<td></td>
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<td>(1)</td>
<td>(0.3)</td>
<td>(4)</td>
<td>(58)</td>
<td>(24)</td>
<td>(2)</td>
<td>(2)</td>
<td>(0.7)</td>
<td>(7)</td>
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Fig. 5.3. Drawing classification categories: (1) enclosure; (2) one-square; (3) foldout; (4) two-squares; (5) drawings with center- Y and base- T junctions; (6) square with obliques; (7) edge with obliques; (8) square with convergent obliques; (9) edge with convergent obliques; (10) dissection; and (11) other.
I shall set aside category 1 drawings since these were confined to two four-year-olds. I shall also combine categories 6 and 8, which contain squares with obliques, since there were very few category 8 drawings. Similarly, I shall combine categories 7 and 9, which contain vertices with obliques. Table 5.2 shows the mean ages of children producing each category of drawing. Categories 2-5.6 + 8, and 7 + 9, in that order, were highly correlated with age ($r = 0.77$, $N = 640$, $d.f. = 5, p < 0.001$).

Three of the categories reveal strong linear trends. In the case of category 2 there is a negative linear correlation with age ($r = -0.90$, $d.f. = 11, p < 0.01$). For category 6 + 8 the correlation is positive ($r = +0.96$, $d.f. = 11, p < 0.01$). Similarly, category 7 + 9 is positively related to age ($r = +0.95$, $d.f. = 11, p < 0.01$).

Peaks for four categories occur in the middle of the age range (categories 3, 4, 5, and 10). But two of these contain comparatively few drawings. Category 4 only contains 5 percent of the children's drawings, and category 10 only 2 percent. Even categories 3 and 5 are never more frequent than 21 percent (age eight, category 3) and 18 percent (age 11, category 5).

The adult data closely match the child data at ages 14 and 15. They differ from the distribution produced by 13-year-olds, $X^2(7,995) = 18.17$, $P < 0.05$, and the lower age groups (and an overall Age (Children vs Adults) by Category chi-square test of independence is significant, $X^2(7,372) = 71.57$, $P < 0.001$).

The most frequent kind of drawing from the adults is the frontal square with parallel obliques (58 percent, compared to 57 percent for 15-year-olds), and its nearest rival is the frontal vertex with parallel obliques (24 percent, compared to 23 percent for 15-year-olds). Apart from the unclassified drawings, no other type is more frequent than 4 percent (T and Y vertices).

The impression given by tables 5.1 and 5.2 is of a developmental progression from a single jumping-off spot to a well-defined terminus. The least variety of drawings is produced by the youngest subjects (for ages 4, 5, and 6, two types classify more than 70 percent of the drawings) and the oldest subjects (for ages 13 and above two types classify more than 68 percent of the drawings). Interestingly, among the eight-, nine-, and 10-year-olds no category holds more than 30 percent of the drawings. There is a diaspora after age five and a refocusing at ages 12-15. Likewise, the greatest frequency for drawings not captured by the 10 explicitly defined categories is found in the 8-10 age range. The eight-, nine-, and 10-year-olds produce 20 percent or more "other" drawings.

In the main, the categories increase in frequency of use, then decrease, several virtually dropping out of use. The adults do not seem to have progressed beyond the prowess of 15-year-olds, and at least a few adults use each category except the lowest (pre-single aspect). The most emphatic trend is from getting a single face of the object correct following a similarity geometry (more than 60 percent of 4-6-year-olds) to getting three faces present, coordinated around a front face or vertex (more than 70 percent of 12-year-olds and older). What is most variable is how other faces are added to the single face before the use of obliques is apparent.

What do the results indicate to be the chief principles in drawing development? Two children at age four show the use of a rounded form, which suggests the extendedness principle. After that, there appear to be two major stages. One could be described as following similarity geometry, meaning that a form on the page matches an aspect of the object. It is reflected in the single-aspect drawing at around age five (approximately 80 percent of drawings at this age), where the cube is drawn as a single square. The second stage could be described as using vantage point geometry. Obliques are employed to show three faces that face a vantage point, as in the square-with-obliques drawing around age 14 (approximately 70 percent of drawings at this age).

How do children advance from one stage to the other? There is no dominant intermediary category, though there is some indication of rather tenuous stages. Foldout drawings are most common at ages 6-8, two-square drawings at ages 7-8, and drawings with Y and T vertices at ages 10-13. But none of them are more frequent than "other" (category 11) drawings at ages 7-10. It is possible that once single-aspect drawing has been mastered in principle, children make a variety of attempts to show the faces that confront a vantage point. They may try to follow a vantage point geometry in restricting the drawing to the aspects facing a vantage point, though initially they may copy the features of the aspects using a similarity geometry. That is, direction from the vantage point is used to select the faces, but not to establish the angles projected by vertices or the line lengths projected by corners. The result is that first one set of the object's features can be favored, then another, none being satisfactory so far as perception is concerned until obliques are used. Then children may begin to realize that line lengths should be foreshortened, and perhaps later they may realize that many angles should not be projected as 90°.

### TABLE 5.2

<table>
<thead>
<tr>
<th>Category Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6+8</th>
<th>7+9</th>
<th>10</th>
<th>11</th>
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<td>Mean Age</td>
<td>4.0</td>
<td>6.7</td>
<td>8.2</td>
<td>8.6</td>
<td>10.8</td>
<td>12.2</td>
<td>12.3</td>
<td>10.5</td>
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</table>
Older children and adults may be attempting to use not only the faces confronting a vantage point but also the directions from the vantage point that produce obliques. They recognize that drawings of faces do not have to follow a similarity geometry.

With these conjectures in mind, Nicholls and I turned to the unclassified drawings. With Carol Flynn’s assistance, we devised a set of possible precursors to the use of three faces with obliques and sorted the unclassified drawings (category 11) with these. If the adult and child drawings were based on quite different principles, this might be evident, we thought, in the unclassified drawings.

The children produced 127 category 11 drawings. The adults produced 65. Nicholls eliminated some from further consideration because the examples contained words, another drawing on top of a first drawing, partial transparency, or lines that could not be deciphered. Types of which there were only one or two examples were also eliminated. There remained 69 drawings by children and 32 from adults—a total of 101.

The difficulty for children, we surmised, resides in adding the third face once two have been drawn. Similarity geometry indicates that the first two faces can be rectangles attached along one side. But how can one show the shape of a third face, and how can it be joined to the first two faces that were drawn? The third face could be a rectangle, a triangle or a rounded form. We categorized the 101 as follows (fig. 5.4). (a) Rectangles are added to one or two squares. Seventeen children (mean age 8.2, s.d. 3.5) added thin rectangles to one square. No adults produced this kind of drawing. Eleven children (mean age 8.2, s.d. 1.7) drew two attached squares and then added rectangles. Again, interestingly, none of the adults drew in this manner. (b) A rounded top or side was added to two attached squares. Six of the children’s drawings took this form, (mean age 9.2, s.d. 1.0). Again, none of the adult drawings took this form. (c) Triangles were added to two attached squares. Nineteen of the children’s drawings took this form (mean age 10.3, s.d. 2.6) and 8 of the adults’.

The last two categories were concerned with obliques: 16 of the children’s drawings (mean age 10.3, s.d. 1.2) and 13 of the adults’. (d) The drawings in this category included diverging lines for the obliques as they receded from the frontal square. (e) Drawings where two attached squares were each given an oblique top were mostly obtained from adults (six adults and one 11-year-old).

It is striking that in this set of 101 drawings, the adults on the whole create the same types of drawings as the older children (mean age 10). The versions offered by the younger children (mean ages 8 and 9) are not used at all by the adults. Adult drawings are probably based on different principles from those that govern drawings by younger children. What might these principles be? One promising account starts from the premise that the dilemma is how to add the third face. The eight-year-olds, still in the sway of similarity geometry, try to preserve angles (90° corners of rectangles). The nine-year-olds reject the need to preserve angles but insist on topological connections (their curved line shows that corners are joined). The 10-year-olds and adults consider directions from a vantage point and aim to show that the top of the cube recedes from the observer, employing obliques for the purpose. Their use of obliques, however, is imperfect. For example, the product is often a triangle on top of a line with a T junction. It leaves the impression that the third face has very unequal angles at the vertices, with the one above the T junction appearing to be 1800. In short, the younger children are matching individual features by copying the right angles, and adults and possibly...
children age 10 and older are attempting to follow a system based on
directions by employing obliques.
In summary, this survey of almost two thousand drawings indicates the
course of drawing development and suggests the principles involved. The
youngest children chiefly draw a single aspect of a figure. Slightly older
children add more faces in foldout style. Still older children restrict them-
to faces in front of a vantage point. The governing principles initially
seem to be feature matching, by which features of the cube are matched on the
picture plane; the number of features being replicated and their relative
positions are highly variable. Later principles derive from directions from
vantage points, which govern the number of faces to be shown as well as their
connections, proportions, and angles. The children, then, are feature-based and
the adults direction-based.

METAPHOR

I do not think that drawing development is finished when vantage point
principles are solidly in place. Once limits and criteria of depiction are evident
to the child, the vantage point stage of drawing development may pave the way for
turning errors to good use. In language we can say, "A teacher opens doors
for students." The teacher does not literally open doors for students to walk
through but makes opportunities available, one of the functions of doors.
Superficially, it is an error to describe the teacher as a doorman. The error, however,
can make a point. Similarly, in pictures one can distort a shape deliberately to make a point. To show the unfeeling landlord's mean ways, the artist can depict his wallet as made of steel. His hands reaching for the rent may be drawn to look huge and hard. The description of the teacher and the picture of the landlord are both tropes, figurative uses of representations. Some trope pictures convey their meaning metaphorically but so aptly they do not need to be explained. For many people, a picture of a miscreant looking contrite while his shadow is doubled over with glee needs no more explanation than a proposition such as "The jailer had a heart of granite."

Since the vantage point stage of drawing development makes drawing precise, errors become salient. Therefore, once the vantage point system is understood, deliberate errors can be made in drawing with the well-founded expectation that the recipient of the picture is likely to discern the error. With ingenuity, the error can be made apt for a purpose. Three distinct purposes of verbal metaphor are to exaggerate, to contrast, and to make an allusion. All of these are evident in pictures (Kennedy. 1982a). Caricatures exaggerate.

Wolves can be portrayed in sheep's clothing. Advertisements try to associate products with wonderful scenery and movie stars.

In addition, some of the devices used in pictorial tropes may involve comparisons between two dimensions. A building's pillars may be shown S-shaped to suggest their shaking in an earthquake. These devices may be used systematically (Goodnow, 1977, p. 116): the more curves, or the more extreme the curves, the more powerful the earthquake. In a cartoon, the surprise and delight as the prodigal son returns home is greater the more extreme the father's pose: his eyes bug out and his jaw drops to the floor. A dimension of variation in the picture thus stands for the relevant dimension in the referent. The features used by the picture to show the referent may be apt and intuitively obvious, but also at times image and referent can be linked entirely by fiat, as in a graph or chart. Skills with diagrams and charts often need to be taught since they can be based on sophisticated conventions. In a diagram, by fiat, length can represent popularity, number of telephones, or bank balance. There is no way of knowing without consulting the key to the diagram. Unlike apt metaphors, diagrams violate the requirement that a picture use elements that spontaneously evoke features of objects in perception.

Metaphoric pictures rest on deliberate errors. In principle, there can be errors once any restrictive rule is established. Deliberate errors, however, are more likely when the domain of pictures is understood. Until that juncture is reached, children may imagine that a particular goal is not solved because of their own limitations, not the limits of the medium. If children know only a few rules, they might interpret an error as permitted by some rule as yet unknown. Errors become salient only when the set of rules is clear and restrictive. Furthermore, since pictures are a means for people to communicate, making pictorial metaphors makes most sense when the error is likely to be understood as an apt error by others. In a stage when the set of rules is unclear, even if a particular rule violation is evident, the child may feel that the error will be overlooked or misinterpreted by others.

Metaphoric drawing development has a different character from the emerging use of the principles of fiat, extendedness, connections, and directions. Each of these builds on its immediate predecessor. Metaphor can be an adjunct to anyone of these principles. It also entails an intuition about others knowing the same rules and deeming something to be a deliberate rule violation. The others have to appreciate the intent behind the drawing. As a basis for metaphor, the vantage point system of drawing is particularly suitable since it is coherent and inclusive, offering rules that are restrictive and consistent. But it only favors the possibility that the child may choose to use
errors deliberately, and metaphors could in principle be offered at any time the child imagines that there is a shared rule.

Metaphoric pictures have another specific characteristic. An algorithm or recipe can be given for vantage point drawing so that any object can be drawn; and any two sketches will in essence be identical. No algorithm yet exists for metaphors. Two thousand years of thought about tropes have failed to devise a procedure for finding the set of apt metaphors for a given topic, in part because the set is infinite and in part because the definition of the term trope is unsettled. Nevertheless, when a person using a device describes it as an intentional apt violation of a rule, it can be classified as a trope. Without being certain of the foundation for the person's claim, it is still possible to classify the device as a trope, for the definition rests on the intention to err aptly.

**IMPLICATIONS FOR THE BLIND**

The first drawing system the child uses emerges from the will to represent, seen in its purest form in representation by fiat, though in the intermediate stages shapes and their locations with respect to the self become relevant, ultimately moving the basis of representation out of will and into perceptual effects. In the earliest stage of representation, typically a work is made and other people are told what it represents. In the later stages, when metaphors are made, the artist bears in mind how other people will interpret the drawing. In both stages, how other people will understand the image matters to the young picture maker. What is in other people's minds is taken into consideration in both stages.

Will, abstract representation, object shapes, perceptual impressions, communication, metaphor, intent, errors, and other minds are all relevant notions in drawing development. Many of these terms apply as much to the blind as to the sighted. Blind people have will like sighted people and understand abstract representation, communication, metaphor, intention, errors, and other minds as much as sighted people do. The unsettled questions, I suggest, are: Do blind people have the same conception of object shapes as the sighted? Do pictorial elements such as outline fit with their impressions of features of surface layout, as occurs for the sighted? Do they think about the task of rendering three dimensions in two dimensions in much the same way as the sighted? Do they make the same judgments of apt metaphors as the sighted? If so, their drawing development could be much like that of the sighted.

Previous chapters examined recognition tasks and reported some drawing tasks attempted by blind adults. The lesson was that object shape and line depiction made sense in the same way to the blind and the sighted. Here I shall report on drawings by blind children. I have selected for detailed study drawings by the youngest children tested in the three research sites my assistants and I have visited and by three older children from the same areas. The three older children show more advanced drawing skills. And I shall consider Tracy, a blind adult who draws notably well, and compare her skills to those of the children and to those of another blind adult, who contends she has trouble with any task involving shape. My assistant in Haiti was Diane Girard, and in Arizona my assistants were Maryanne Heywood and Jay Campbell.

**Cel**

The youngest Haitian we tested was Cel, age six, blind as a result of malnutrition. Cel was admitted at age three to the school where Diane Girard and I tested him. At that point he was recorded as totally blind, and we may reasonably conjecture that Cel has had no pictorial experience since going blind and probably had little if any pictorial experience while sighted. He made seven pictures in one interview if we count false starts as well as completed pictures. The five pictures Cel deemed complete are in figure 55.

Cel's drawing of a coat hanger has a square enclosure rather than a triangular one, but the hook and the shoulders and straightness of sides around a central region are clear (fig. 5.5a).

After drawing a single closed form to depict a ring, Cel was asked to show the thickness of the ring. He drew two overlapping square-like regions (fig.5.5b).

He depicted a box with square top and bottom and rectangular sides by four long horizontal lines. He indicated that each line stood for one side of the box. He finished the drawing with two vertical lines, standing for the top and bottom of the box (fig. 5.5c).

He drew a glass as an enclosed area for the open top, four lines for "the sides," and a line across the ends of the four side lines for the bottom. He explained the four vertical lines by touching the glass at four equally spaced intervals around it (Fig. 5.5d).

For a table, he drew an enclosed area ("the top") and put four parallel lines inside the area ("the legs") (fig. 5.5e).

Cel used the shapes of lines for legs, a hook, and the lip of a glass. These features are shown in outline using similarity of shape. Cel also used straight lines for whole flat "sides" of a box. In Willats's (1981) terms, a one-dimensional mark (a line) stands for a two-dimensional referent (a side). The line may show straightness or flatness and extent, not how the side projects to a vantage point. Therefore, this mayor may not be the outline style, where a line stands for change in relief at corners and occlusions. Certainly Cel violates
Ros, 16 years of age, also from Haiti, is early totally blind. The cause of her blindness is well established, a rarity in Haiti. Both of her eyes had to be removed surgically at 18 months following bilateral retinal blastosis. Her experience in making drawings was therefore minimal if any prior to blindness and after blindness has been none so far as one can ascertain. Further, since the blastosis was inevitably present for some time before the operation, visual experience with pictures must have been slight. During one interview Ros drew 18 pictures (perhaps 16, for two pictures are probably two linked parts). Four are shown in figure 5.6.

Ros began by drawing a bracelet. Of three attempts, Ros, laughing, said the one in figure 5.6a was the best. It was rounder than the others.

Drawing a coat hanger (fig. 5.6b) Ros again laughed, saying, "It's not very good."

Her table (fig. 5.6c) is notable. It is long and thin with two legs at each

this outline style in using lines for the straight front and back of a glass showing their extent. Also, the line encircling the region showing the top of the table probably is not showing the shape of the tabletop. Rather, a region in the picture surface is representing a region in the world, and they extend equally in two dimensions. Concern for connections is fickle. The hook is connected to the shoulders of the coat hanger, but the legs are not connected to a table perimeter (probably because the line does not depict the perimeter in the first place). The fact that the legs are part of the table may be shown topologically by having the legs inside the region representing the tabletop. But in a feature that follows similarity geometry the fact that they all go in the same direction in the referent may be reflected in their being parallel in the picture. Their direction with respect to a vantage point probably is never considered by Cel. In sum, Cel seemed to make inconsistent use of outline, similarity, extendedness, connections, and possibly the directions of parts of

the object to one another. In terms of the two main drawing stages, Cel's drawings sometimes achieve the single-aspect stage.

Fig. 5.5. Five pictures by Cel (totally blind at age three): (a) coat hanger; (b) ring; (c) box; (d) glass; (e) table.

Fig. 5.6. Four pictures by Ros (early, totally blind): (a) bracelet; (b) coat hanger; (c) table; and (d) glass.
saw progress remarkably in drawing principles in a matter of minutes and without any instruction from us.

Di

Di, six years old, the youngest child in the Phoenix study, has been totally blind since birth. Di had made raised-line drawings of a face and a spider before commencing our tests, but so far as is known she had not been given pictures prior to our interviews. She made seven pictures for us. Six are in figure 5.8.

Di began by trying to draw a coat hanger. She found it easy to draw a horizontal line for the base of the hanger. But then, when she tried to draw diagonals for the sloping shoulders of the hanger, she found she could not produce the lines she wanted. (Most children, as Olson [1988] noted, found diagonals difficult) She ended up with another horizontal line, parallel to the first, and then would do no more (fig. 5.8a).

end the lower ones meeting the lines for the sides of the table at acute angles, the upper ones more normal to the sides.

Her glass (fig. 5.6d) has U-shaped sides, and the mouth is shown by a single straight line at the top of the U.

Ros's drawings are more restricted to outline style than Cel's. The connections of the lines are made frequently, and they appear in suitable locations. Ros never made explicit reference to a vantage point. She herself was discontented with many of her drawings and seemed very defensive. At times she laughed rather than respond directly to questions. In Diane Girard's succinct observation, she was "giddy." We did not push Ros, out of concern for her discomfort, but I should add that the drawings here do seem to me to be her best drawings, and with each fresh start Ros did seem to make a more sophisticated drawing. By way of illustration, figure 5.7 shows Ros's first drawing of a glass. Notice that the length, mouth, and bottom are all shown by separate lines. The length is one set of lines, while the mouth and bottom are each shown by separate lines that happen to cross one another. It is a great leap to the second glass drawing (fig. 5.6d) which uses lines in outline style, with proper shape and connections. The first drawing simply marks lines that Ros then announced to be whatever feature of the glass she considered next on the list of features to be shown. The later drawings use outline in foldout style to depict occluding edges of flat objects and bounds of rounded objects, as well as parallel features such as wires and legs. Ros has clearly made some progress beyond the single-aspect stage. She was not the only blind person we

Fig. 5.7. Drawing of a glass by Ros (early, totally blind).

Fig. 5.8. Six pictures by Di (early, totally blind): (a) coat hanger; (b) ring; (c) bottom of a box; (d) man; (e) spinning wheel; (f) L-shaped block.
Di next drew a ring (fig. 5.8b) and the square bottom of a box (fig. 5.8c). A hexagonal box was offered to her, but Di refused to attempt to draw it.

Di next drew a man (fig. 5.8d) and a spinning wheel (fig. 5.8e). She identified the parts of the man (eyes, nostrils, mouth, neck, etc.), all of which lie in the proper locations. She accomplished this drawing after somewhat directive questions from us: "Have you drawn the mouth? Where would you put it?" Her drawing, with this kind of supportive questioning, is much like those of sighted 2 1/2-3-year-olds (Wolf, 1983; Golomb, 1990) under the same testing conditions.

Di said that she did not know how to draw a running man, and refused our request to try. On the other hand, she drew a series of circles and then straight lines for spokes when asked to draw a spinning wheel. We asked her, "Can you show it's spinning?" She replied, "I did." "How can you tell it's spinning?" "Because I can really tell when it's spinning." "How does the picture show it's spinning?" "Because."

We asked Di to draw an L-shaped solid object. She drew an L made of two straight lines. When we asked her to draw a T-shaped solid object, she drew a figure that does not follow outline style but is nonetheless revealing (fig. 5.8f). Di first drew two separate marks. She indicated that one mark stood for "the block," seemingly the whole object. The second mark, she said, was "the long part" of the block. When asked about the short part of the block, she drew a separate third, circular mark. We asked her if she could put the marks together, the way the parts are together in the block. She said no.

Di's first drawings include aspects of outline. The features she chose fit with outline style (wires and edges of objects). Shape is repeated on the page, emulating the object. Shape that is incorrect was rejected. In the somewhat "dictated" drawing of the man, locations are correct. In the wheel, however, spokes are disconnected from the circles. Movement is understood to be depicted but has no features on the page that can be pointed out. The motion is represented merely because it was intended. In the T-shaped block, one mark stands for the whole, it seems, while other marks Stand for parts, and no connections are drawn. As in the drawing of motion, what matters is what the mark is intended to show. Di's drawings sometimes reach the single-aspect stage of drawing, but not always.

Hal

Hal, age 10' from Phoenix, has been totally blind since age 21/2, when he was blinded by contact with chemicals. Since then he has made some drawings with crayon on paper (leaving tangible tracks) or grains sprinkled on glue, and he has read some of the Expectations series of Braille books that contain illustrations.

Hal made 31 drawings for us, including several attempts at some objects until he felt reasonably satisfied and some drawings he drew at his own behest. Ten of Hal's drawings are in figure 5.9.

Hal drew a ring as a circle and then "went around it on the outsides" to show that the ring was thick (fig. 5.9a). For a rectangular box with square cross section, he drew a rectangle and then "like the circle, I went around it to show its thickness" (fig. 5.9b). But for the hexagonal box, he said "going over it" would show "the sides" and that "would not work." He went on, "The
only way is to show one side, and another, and another," while he rolled the hexagonal box across the drawing surface. He drew six separate rectangular sides (fig. 5.9c). When we asked him what the lines stood for, he indicated the corners. We asked him if there was any special reason why there are two lines at each corner. He said, "No, that's just the way I drew it." His comment is reminiscent of Willats's three-line corner.

Hal next drew a man (fig. 5.9d). Then he volunteered an elegant stick figure drawing of a dog (fig. 5.9e).

Hal made three attempts at drawing a Static wheel, rejecting two because they were "not good circles." For a spinning wheel, Hal added extra loops around the outside of the wheel (fig. 5.9f) to show movement. In another drawing (fig. 5.9g) he distorted the wheel's shape from circular to oval, and he arranged the spokes in a line to show "one spoke would come right after another." It differs from his static wheel, which was drawn with spokes largely arrayed around the center (fig. 5.9h).

We asked Hal to draw some cubic objects—an L block and a T block. For the L, he drew separate faces, one L-shaped and one rectangular to show the thickness. In another drawing, he also drew the L but then added radiating lines to show the thickness. For the T, he again drew separate faces (one a T, one a rectangle, one a square). He returned to redraw the T, this time adding radiating lines to show the thickness (fig. 5.9i). He said that the radiating lines indicate "the sides that go up" and show that the enclosed space is "the middle."

Included in a set of drawings from a second interview a few days later were stick-figure people in a circle, a glass as a U and then as a circle to show the roundness, and a pair of drawings of a table. Figure 5.9j is a drop-leaf table. It is drawn from the side and has rubber ends on the legs. Beside it he drew a drawing of the "top part" (now round). When asked, "Can you show he legs?" Hal replied, "No, they're down here," pointing below the paper and the surface it was resting on.

Hal draws well and, as Maryanne Heywood put it, within minutes "pictures were improving--neater, straighter lines, more accurate angles." He uses shape similarity and outline style frequently. He connects the parts of objects appropriately in many drawings, but he also draws separate rectangles for an object he is "rolling" in his mind across the picture surface. He departs from outline style to show thickness, to add arcs around a spinning wheel, and to break the arrangement of spokes in a wheel to suggest movement. Hal is aware of the vantage point for his drawing of a table with the legs omitted.

Hal left US with intense respect for the 10-year-old mind's capacity for solving problems of drawing and with virtually no sense that blindness is a bar to use of outline or to pictorial inventiveness. Hal copies die shapes of aspects of objects. He uses foldout style. He shows some aspects of vantage-point style in drawing a table. His departures from outline style are marked at times by his own comments as "somewhat different."

**Lu**

The youngest child in the Tucson study was Lu (age 5, totally blind since birth). With her mother especially, Lu has made some cutouts, some of which have pictorial aspects, and string designs, some of which are rudimentary pictures. She owned an outline drawing of a hand before our testing program, cut out puzzles of a swan and a dog, and some relief displays of animals.

Lu began with a coat hanger (fig. 5.10), drawing a hook, then some disconnected lines for the neck, then a single line for the bottom and a series of lines, some slanting, some parallel to the bottom line. Her method solves the difficulty in drawing a diagonal by using one long line for the extent of the shoulders of the hanger and shorter ones to show diagonality. Apparently Lu has depicted the two properties separately.

For a ring, Lu first drew a large circle and then said, "Now I have to draw the inside circle" (fig. 5.10b). When we asked her what parts of the ring she had drawn, she indicated the innermost and outermost bounds of the ring.

We gave her a cubic box and a hexagonal box to draw. Her drawing of the cubic box was a series of loops and curved lines, and when asked what part of the box she had drawn, she indicated the edges of some faces. She described her drawing of the hexagonal box (fig. 5.10c) more definitively. She counted six sides of the box and drew the box twice; the second drawing is shown in the figure. Lu first drew six curved lines, counting aloud from one to six. Then below these she drew another curve, saying, "And now the bottom," and above she made another curve, saying, "And now the top." Her second drawing began with a long straight line, to show that the box had long straight sides, she said. Across this line she drew six circular arcs, again counting from one to six. When we asked her what the arcs mean, she replied, "The six sides."

Lu began the interview with outline drawings--lines for wires and boundaries. But the box drawings provide marks that stand for faces of the objects without regard for the shapes of edges. These drawings have marks that refer by fiat, not shape. They do keep the number of facets correct, but features are in a sense shown twice, since the length of the side is shown by a long line separate from the lines that stand for the sides. This is a drawback to the fiat system, which surely is overcome when the child realizes that a copy of the
He plays guitar in public and now speaks English well. Raf was careful in his drawings, d1atty, thoughtful, and good-humored. Before our tests Raf had made some string designs but no pictures. He had been given maps, but not pictures, in school Raf made 12 pictures in two sittings, including several starts at Some objects. Four are in figure 5.11.

Raf began by drawing a coat hanger (fig. 5.11a). Next he drew a ring as a single line. To show the thickness, he said, "You could make it over, I guess--right next to it, around the outside." He added an outer line (fig. 5.11b).

Drawing the cubic and hexagonal boxes, Raf drew faces of the boxes (fig.5.11c).

To show a man running, Raf drew legs with a kink in them. "It’s just

object shows length, shape, and number all at once. Lu's drawing of a ring is her most advanced, belonging to the single-aspect stage.

Raf

Raf, age 12, has light sensitivity but cannot make out shapes visually. He has a grade five education level but has been attending school only for three years, following his arrival in Tucson from Mexico and with no English-language skills. He is considered extremely bright and is talented musically.
showing that his leg is bent. You know, when you run you sort of bend your leg." And he said "you could put one of those things they have to jump over" and he added a hurdle below the man (fig. 5.11d).

Raf used outline for relief features. He also used similarity of shape. He drew single aspects of objects, and he added a hurdle as a context, in outline, to confirm a referent. One cautionary note: Raf did not mention vantage points. Indeed, when we asked him what the lines for his ring meant, he did not indicate, as did Lu, the inner and outer bounds. He traced an area on the ring with his finger somewhat in from the extreme bounds.

Raf's delightful picture of a running man was selected for the cover of the January 1983 issue of American Scientist. What a charming eventuality for a boy who came to Tucson at the age of nine with no previous schooling--to have an ability uncovered a few years later, and to have that ability recognized throughout his adopted country.

**SUMMARY AND INFORMATION ON GROUPS OF CHILDREN**

We have now studied six children in some detail. Each of them uses outline and similarity geometry in some drawing, the youngest children reaching the single-aspect stage of drawing. There are other kinds of drawings, too, including foldout and occasional vantage point drawings from the older children. What can be said about the children as a group? Since the Haitian children fared poorly when asked to examine drawings, we must especially take account of them to demonstrate that drawing is universal.

In Haiti every volunteer made at least one outline drawing with similarity of shape to the referent. The Haitian children were asked to draw a coat hanger, a bracelet, a ring, and a table. Let us consider each in turn.

A drawing of a coat hanger was deemed recognizable when the overall form was present, with the line standing for the hanger wire and a hook connected on the outside to an enclosure. If we include Cel's drawing in this category, then 13 of 15 coat hanger drawings are recognizable.

The bracelet was a single rounded form in 12 of the 13 drawings we obtained. The bracelet's shape was shown and the line stood for a wire forming the bracelet. The thick ring had two concentric circles in 12 of 14 drawings (fig. 5.12, by Ron, age 11, blind before age two).

The table was a closed shape for the tabletop (fig. 5.13, by Ren, age 15, blind before age seven) with four legs in 14 of the 15 drawings. The exception was Man's (age 12, blind before age five). whose tabletop shape is hardly closed (fig. 5.14). She also drew only two legs (the two smaller regions in the figure). Man's drawing is reminiscent of the drawings of coat hangers where parts are drawn disconnected. The other 14 drawings are an advance on Man's, adding more legs and appropriate connections.

Now let us consider the coat hanger, ring, and box drawings by the Phoenix and Tucson children.

In Phoenix, five of the children drew the coat hanger recognizably. Another five drew parts--Sean, age 6, only drew the hook, for example--or drew several parts without connecting them, as Di did.

Three of the children drew a ring as a single circle (Di and Sean, both age five, and Rae, age eight). Four drew two concentric circles and three drew "extra lines," that is, redoubled lines, to show the thickness.

For the cubic box, three drew separate lines and indicated that lines stood for sides of the box (not edges) or the "whole front of the box" (Noel, age 12). The other children drew faces of the box. Kim, age eight, said she drew the top and bottom faces, the top with a circle and the bottom as a neat square, with a space in between. We asked her about the front face of the box, and she added some short lines linking the top and bottom, saying that this was the "up and down part." While Kim's box seems to have lines as linkages (which
is not outline style) and a circular region standing for a face (which probably shows how the face is extended rather than any similarity of shape), in the form of a square it displays a well-defined use of outline and similarity geometry.

The hexagonal box drawn by six children included indications that the lines stood for edges or corners. Ted, age 14, noted that you could draw a part of neighboring sides to show that they "angle off," as he put it (fig. 5.15). In less advanced sketches, four children indicated that the lines they drew stood for sides, not edges or corners; they counted sides and drew one line for each.

Evidently, many of the children tested in Phoenix sometimes used lines standing for edges according to similarity geometry. The most dubious case was Erl (age 13), who was functioning at grade 3 level in mathematics and reading and was receiving special aid. He drew circles for the ring, which seems appropriate, but his coat hanger is merely a series of horizontal lines (which he labeled hook, top, and bottom, in that order). Likewise, the cubic box is a series of vertical lines--left side, bottom, and right side, in his order. His hexagonal box is made up of six lines, which he called six sides. He seemed to note the features in order and draw one line per feature most of the time. This simplicity is not a sign that Erl was uninterested in the task. He volunteered a drawing of a "plastic squeeze ketchup bottle"--a pair of concentric circles for the bottom and some vertical lines as "the front of it," accompanied by a comment that he could not figure out how to draw the nipple.

Among the Tucson children, five drew the coat hanger With its overall form displayed, reaching the single-aspect stage. One disconnected the parts (Lu, age five), and one is a series of lines with no clear description (Lar, age 14).

The ring was drawn as a pair of concentric circles by five children—and perhaps by Lar, who drew several circles, possibly four, and said, "It goes around and around and around." Tim (age 6) drew a circular squiggle, a filled-in patch, and said that it shows the ring "all over."

For the cubic box, five drew a square. Tim drew a squiggle and called it "the box." Lu drew a squiggle and pointed to several sides of the box when asked to explain her drawing.

For the hexagonal box, two drew at least two faces (Jef, age 12, and Ole, age 14). See figure 5.16, by Jef. Two drew a rectangle. Lar drew one line per side, and Lu drew lines for each of several features including length. Tim drew six lines standing not for faces but for corners, as he indicated in response to questions.

For each object, the typical response was in keeping with outline Style. Single facets, drawn in shapes governed by laws of similarity, were the chief response. But as usual there are other aspects of the drawings to be accounted for. One line per side is common, and occasionally the drawing represents the object solely by fiat. How can these non-outline aspects of the blind children's drawings be characterized, and how can the prowess with outline be fitted with the rest?

The prime source of drawing is not that marks such as lines can resemble features of the world such as corners, edges, and wires. The will to represent comes before the ability to make resemblances, for the blind as well as the sighted. Nat, a blind adult in his thirties when we tested him in Toronto, remembers wanting to try to draw as a child even though he was told he could not draw because he was blind. Sighted preschool children make marks they call "cars" and "hammers" although shapes similar to the cars and hammers 'are not apparent in the drawings. Cel drew a cubic box with four straight
Thus the will to represent--to choose, by fiat, to let any mark stand for
anything--comes first and persists while other abilities develop in the blind
child. This substratum is vital in every stage because it means that the limits in
any method of drawing can be overcome. The child can reach the limits of any
method and then settle any outstanding needs by asserting that they have been
represented by marks chosen at will. The will is still present in adults, of
course, as we find in a shorthand list for a trip to a store. Instead of writing out
every word longhand, someone might end a list with asterisks and exclamation
marks as a reminder to buy thumbtacks and a Frisbee. (If the marks were to be
less arbitrary, they might be a swirl as a reminder to buy a Frisbee, dots to
mean thumbtacks, stars to mean decorations, and an exclamation mark, as: a
reminder to buy fireworks.) The shorthand list would be an adult employment
of the will to represent shown in the "list" drawings of children.

The list drawings of blind children become more sophisticated when the
marks are placed in proper order, the one for the hook above the ones for the
body of the coat hanger, for example. This presumably enables a major
advance on list drawings, to make not just any mark but a mark whose shape is
relevant to the shape of the object. Lu's coat hanger has a curve, oriented
properly, for the hook, vertical lines for the neck, and so on. But the parts are
not connected. Cel's table has an enclosed area ("the top") and four straight,
parallel lines ("the legs"), but the lines for the legs are not connected to the top.
The objects are drawn piecemeal. Conceivably, each item could be drawn in an
arbitrary location, with no special orientation, but I have never seen a drawing
like this. Lu used placement, and Cel drew all four "legs" parallel within the
enclosed area standing for a tabletop. Hence, placement patterns (Kellogg,
1969) probably precede outlining individual features. Wolf (1983) notes that
sighted children ages 3-4 occasionally draw objects in this disconnected
fashion for a brief spell, perhaps 2-3 months. It may be fairly common in blind
children of an older age, for Lu is five and Cel six. Adults retain the capacity to
draw objects piecemeal. We use the system in so-called exploded diagrams,
where machines are drawn with their parts separate to make each part clear.

Just as outlined parts are an advance from list drawings because they add
relevant shape, so too adding connections is an advance from piecemeal
drawings. If the parts are connected, objects like the coat hanger would be
drawn with a recognizable overall shape. The boxes would be drawn with each
side neighboring another. They would appear as though folded out, in the
manner of a cardboard box that has broken down and lain flat on a floor. Hal's
box showed "one side, and another, and another" as he rolled the box across the
drawing surface. Ros's table is reminiscent of a card table that has had its legs
folded out. In this system the front, the back, the top, the bottom, the left sides,
and the right sides can all be shown. Each part is drawn in outline style; each part is connected with another; the arrangement of parts on the page follows the order of connections in the object. Willats (1981) notes this kind of drawing in sighted children roughly 7-8 years of age. Table 5.1 shows that it peaks at eight years but is common from six to nine years (where it comprises more than 10 percent of the drawings from sighted children).

As adults we still sometimes draw this way. Car rental firms, for example, provide foldout drawings of their cars—the top in the center, the sides folded out like wings, the back and front folded out like extensions of the center. The rental agencies put on this drawing any scratches or dents on the car they supply to avoid arguments later.

Foldout drawings can be complete drawings of the object, but they fail to show how parts "angle off," as Ted put it. Nor do they show the location of the object. What is to the front, the back, the right, and the left? All the sides are drawn without discriminating their orientations.

An advance on foldout drawings is found in Hal's drop-leaf table. He drew the table once from the side and once from above, showing the location and orientation of parts with respect to a vantage point. The line now shows the arrangement of the tabletop, with one side near and the rest of the tabletop behind the side, hidden. When the table is shown from above, the legs are not drawn because from that vantage point they are behind the tabletop. This drawing surely indicates that Hal was grappling with vantage point issues. Willats (1981) notes this kind of drawing in nine-year-old sighted children, and our study of drawings of cubes suggests that sighted children ages nine and above are struggling with applications of vantage point geometry.

Whereas foldout drawings allow all the parts of an object to be shown, vantage point drawings provide a way of omitting parts systematically. Hal's table drawings shapes are shown correctly, what connects to what is shown correctly, but also a vantage point is used to eliminate some parts and provide a consistent orientation for the remaining parts.

As with the adult blind subjects, there are few hints of changes of angle and convergent perspective in the children's vantage point drawings. Hal's tables are from above or from the side, not from a three-quarter angle. Perhaps Ted's drawing of a hexagonal box, where wisps of line at the top and bottom of a face indicate how the neighboring sides" angle off," reveals a premonition of convergence. In sum, two drawings indicate clear use of a vantage point.

Although convergence is not demonstrated overtly in the drawings, something else is that may be an important advance beyond single-aspect drawing. Hal initially drew a static wheel as having a circular form with spokes arranged around the center. To draw a spinning wheel, he changed the shape of the wheel and modified the arrangement of the spokes. The wheel was now elongated into an oval, and the spokes were set in a line to show that "one spoke would come right after another." How different this is from the drawings of childlike Di, who "knows" that the wheel is spinning or can only say, "I made it spin" or "It's spinning because I can tell." Hal's distortions suggest he knows that the drawing of a static wheel will not do, and that he has come to the limits of shape and outline.

The shape of an actual wheel does not tell us whether it is spinning or static. Neither does its outline. But the will to represent is broader than the ability to make things resemble their referents. That ability is present before successful resemblance is achieved, and it persists whenever any ability reaches its limits.

The ability to make anything represent anything we want explains part of Hal's drawing of a spinning wheel. But there is more. Hal does not simply make a mark, a squiggle, or a line and declare that it means the wheel is spinning. Rather, he violates a success he has already shown confidently in drawing a static wheel—that is, he modifies. His tactic is not like filling in a space between points because there is something missing (as Kim did to connect "top" to "bottom" parts of a cubic object). Nor is Hal's tactic like drawing the whole object and then, when asked about some parts, adding them as afterthoughts (as Di did to draw a cubic object). Rather, he redraws the object.

**TRACY'S CUBES**

At the outset of this chapter, I noted two drawings of a cube by Tracy, a blind woman age 28. The first was a square with four arcs, one per comer. The second was two squares joined along one side, with a curved line connecting the top left and right comers of the squares. To anyone unfamiliar with sighted children's drawings of a cube Tracy's drawings are puzzling. Where, if anywhere, do they fit in normal drawing development?

Tracy's first drawing contains a square. This is her depiction of a cube as a single aspect, the chief method of drawing a cube for sighted children ages 4-8. Tracy's first drawing of a cube places her clearly in a major stage of drawing for sighted children. The drawing also contains four small arcs, which Tracy described as ways of showing "angles." She said that marks like these were drawn at angles in her mathematics classes. Evidently the arcs are a conventional prototype borrowed from a familiar setting.

Tracy's second drawing vaults her abilities beyond single aspect. It shows two squares adjoined, which Willats in his study of sighted children makes his fourth drawing stage. But in addition it contains a curved line joining two
outer comers. The age at which we found sighted children drawing like this was nine years. When asked what the curved line stood for, Tracy said it represented a part of the top surface of the cube. She traced along an arc from one top vertex of the cube to another vertex diagonal to it. The arc curved toward the rear corner of the cube but did not touch it. She was asked if the line stood for the rear edges of the top face, and she said that it did not. The line seems to show that there is a connection between the left and right vertices of the cube rather than depicting an edge.

The curve of the line is shallow, but the arc followed by Tracy's finger across the top of the cube was more like a semicircle. This may indicate some foreshortening, since the top face is horizontal. The conjecture makes sense in the light of a third drawing of a cube by Tracy (fig. 5.17).

Tracy was asked to draw a cube sitting on a table. The drawing contained a square and a rectangle. The rectangle atop the square shows the top surface of the cube above the front face of the cube. The rectangle is much thinner than the square to indicate that it is a face receding from the observer. Thus the drawing uses foreshortening. Her first use of foreshortening in our studies was in drawing a card folded in the middle and set on edge. The card formed two equal rectangles with a rectangle facing Tracy and a rectangle slanting away. Tracy drew this just before the square-and-rectangle drawing of a cube. In sketching the card, she drew the facing rectangle in proportion and the rectangle slanting away as thinner (fig. 5.18). Katz (1946, fig. 14g) reports a similar drawing from a blind student.

In her drawings, Tracy's use of two faces and foreshortening places her solidly in the vantage point stage of drawing development, a stage more advanced than that of many if not most sighted nine-year-olds. Her drawings of a cube seemed to advance rapidly in sophistication with each attempt,

Fig. 5.17. Third drawing Of a cube, by Tracy (early, totally blind).

moving from a drawing characteristic of five-year-old sighted children to one more typical of 9-10-year-olds.

Tracy drew several figures at my request and volunteered a few drawings of objects of her choosing. One of these may be sufficient to make the point that Tracy drew at least as competently as most sighted 10-year-olds. Figure 5.19 shows a cat. Tracy reported that this was her own cat's favorite posture.

Not all blind adults draw as well as Tracy. Some, like her, have a keen interest in shape and form. Others demur when asked to undertake any project that has to do with shape. They protest that they always have trouble with maps, diagrams, and spatial directions. They report that in school they always felt like failures at spatial problems. They say they try to avoid dealing with form. Like fears some people have about mathematics, computers, or athletics, these fears may be based on initial difficulties but can become self-fulfilling prophecies, preventing the person from advancing in a domain of expertise where they may have appreciable if modest abilities.

Consider Kathy R, age 41, from Ottawa, totally blind at birth. She reports that in school she always avoided tasks that had to do with shape since me felt that she could not succeed in these tasks. She notes that she cannot easily follow spatial directions and she says that she "has to walk it." Even after

Fig. 5.18. Drawing of a card folded in half, by Tracy (early, totally blind).

Fig. 5.19. Drawings of a bird and a cat, by Tracy (early, totally blind).
walking a route, she finds she cannot easily make the return trip. I wonder if she has set her own standards for success so high that she is bound to fail.

I asked her to draw a cube. Her first drawing was a rounded closed form (fig. 5.20a). She added squiggles and pairs of parallel lines to the closed form to indicate features of the cube such as the top or side faces. She puts some of these marks inside the closed form and some outside. She was not pleased with her drawing and started another. This one had two faces, but they were separate and still rounded (fig. 5.20b). A third drawing of a cube also contained two forms, but now both were rectangular and they were connected (fig. 5.20c). A few additional marks and squiggles were meant to show which is the top face.

In a matter of minutes, Kathy moved from a rounded form (the first of Willats's stages) typical of 3-4-year-old sighted children, to two joined rectangular forms typical of a child age 7-8 (Willats's fourth stage). The principles she was grappling with in the third drawing are matters of vantage point geometry, since only the aspects of the cube facing her are drawn. She was also using similarity geometry, showing rectangles by rectangles although they are not well executed. Evidently she has a fairly definite sense of similarity of shape, for she corrected her final attempt at a cube's front face. It was initially drawn as a rectangle about 1 cm by 3.5 cm, and she corrected this to 2 cm by 3.5 cm, noting that this was better but not perfect.

Kathy also drew a man standing and a man lying down (fig. 5.21). The man standing has both legs in the same direction as the body. The man lying down has his legs at right angles to the body. The forms in both drawings show an ability to use similarity geometry, lines for limbs, and rounded patch shapes. The method of drawing the man lying down shows an ability to vary the relative orientation of parts to invent suitable devices.

Kathy's ability was not the equal of Tracy's. Her performance was like a sighted child's of age 3-8, depending on the task and how many previous attempts Kathy had made. Her ability is not negligible, though her remarks indicate that it does not satisfy her. Her drawings, more than her remarks, reveal an ability ready to be tapped, challenged, and refined. Her own problem-solving abilities, unaided, produce refinements. With suitable encouragement she might quickly progress to a basic understanding of as many

Fig. 5.20. Three successive drawings of a cube by Kathy (early, totally blind). By the third drawing, shapes of faces of the cubes are evidently presented in similarity geometry.

Fig. 5.21. Drawings of a man lying down and a man standing, by Kathy (early, totally blind).
problems and principles in drawing as Tracy has. Although Tracy may have a better grasp of edges, proportion, and ways of checking and modifying a drawing, Kathy seems to move swiftly from one key principle to another, more advanced one. A teacher of nine-year-old sighted children once described to me some of her drawings as "chicken scratches." Kathy's drawings have this appearance at first, but the ideas she was using to guide her drawing were like Tracy's. For example, Kathy said that to show a box set in the middle of the table, as opposed to near the front edge of the table, she should "make it smaller a little bit but not much." To show the box on the far side of the table, "the box would be a lot smaller." To show a folded card, the part receding should be shown with lines mat" as they go away from me ...get thinner," and the part nearer should be "fatter to indicate it's closer to me." Kathy's ideas are advanced, though her execution often lags behind them.

I conclude that Tracy and Kathy both fit into normal drawing development. Both show major principles of the main stages of normal drawing development, similarity geometry and vantage point geometry. One is extremely interested in shape and has enjoyed self-guided exploration of outline. The other is concerned about her abilities with form to the point of avoiding any tasks having to do with it. Yet both progressed rapidly so far as drawing development is concerned when asked to draw a cube.

Early beginnings are laden with promise. Blind children, like sighted children, make marks and call them objects. They put marks in proper locations with respect to one another following their relations in the object--top, middle, bottom, left or right. At first, blind children draw with a variety of marks standing for corners, faces, and whole objects. They often draw in outline, choosing lines to stand for wires, rounded bounds of objects, and corners of objects. On occasion, particularly with younger children, me parts are disconnected but distributed in a way that matches their locations in the object. Many blind children draw connected parts in a foldout version of objects. Twice in our studies, a vantage point was used explicitly to govern me selection of parts and their arrangement.

Wolf (1983), Willats (1981), and others have found these same kinds of drawings in sighted children. The set of advances I have described here would be accepted by many students of children's drawings of space and shape. What is salutary is mat me drawings presented here come from me blind. Many scholars would have argued that much of children's drawing ability is a product of being taught formulae and being given rules or expectations. For sighted children, mere is a great deal of truth to their arguments (Wilson and Wilson, 1982a and 1982b, Wilson, 1985), though even with me sighted it is not me whole story. Yet these arguments are unlikely to explain how blind children come to draw.

Blind children are not taught to draw. They are not given formulae by their teachers (or schoolmates) and do not acquire them as prototypes, like Snoopy in the Peanuts strip, as sighted children do. Ramer, they seem to be driven by some developing ability mat grows and burgeons unknown and unsuspected in all blind children. It only needs tapping to make itself evident.

This talent grows without direct tuition. Tracy and Kathy seemed to advance without guidance. The talent grows even when denied. Nat was told by his teachers that he could not draw and it was not worth his while to try. Yet he drew many pictures in our research program, and one was picked for me May 1980 cover of New Scientist. The journal, appropriately enough, gave Nat the cover artist's fee for his drawing. To my knowledge, this makes Nat the first blind man in me history of publishing to be given me cover artist's fee from a magazine--a special moment for publishing, for me psychology of pictures, for me blind, and for Nat.