CHAPTER FOUR

Drawings by the Blind

To ask blind people to draw is to ask people unfamiliar_with pictures to show solid objects by means of flat paper and marks on the paper produced by a Stylus. The task is one that young sighted children happily take on themselves. Like sighted children, blind people can be novices at drawing, but if they are articulate adults they can put into words some of the difficulties they meet in trying to draw. In this chapter, I shall examine the outcome of drawing tasks given to blind volunteers (adults and children) and discuss some of the ".issues raised by the participants.

My chief aim is to show that blind people draw using the same outline system that governs their recognition of haptic pictures. I shall provide examples of blind people using lines to stand for occluding edges of flat surfaces, occluding bounds of rounded surfaces, and single lines standing for features like wires. A secondary aim is to show that the patterns of lines produced by the blind are appropriate rough copies of the shapes of objects, demonstrating how the parts of objects are laid out with respect to each other and the observer's vantage point.

The axis theory of outline that I have presented in the previous chapters predicts that lines will be used by the blind to stand for features of surface relief. The amodal theory of spatial apprehension anticipates that blind people should try to depict the same spatial arrangements as the sighted. But depiction is a skillful act. It is not easy to step from what we know to what we can represent. Blind people might scout around attempting to use lines for a variety of features other than the ones that might capitalize on their abilities with axes before realizing the effectiveness of using lines to represent relief features. Spatial arrangements in three dimensions cannot be replicated on a sheet that only has two. Precisely how the novice might attempt this rendering of three via two is not something the amodal theory can predict. There are many ways three can be approached via two and many ways that the amodal sense of solid shape could influence sketches on a flat surface. I use the cautious term *influence* advisedly, because the intuitive understanding of amodal shape that allows us to recognize an object is only one of the factors governing drawing. Other players in the story will make themselves known as we proceed.

BLIND ADULTS DRAWING A HAND

The first drawing studies I undertook (Kennedy, 1980) were with adult volunteers from BOOST in Toronto, and the tests were conducted with the assistance of Maryanne Heywood. The studies were undertaken in response to two incidents in picture-recognition studies and a ground-breaking report from Susanna Millar (1975). Betty (age 14, who has large object detection visually) mentioned a long-term interest in drawing: "I was taught how to make lines and circles. I put them all together myself to make drawings." Pat (early, totally blind adult) on her own initiative made a drawing of duck's feet that was surprisingly good for a first drawing. These incidents suggested that there was both spontaneous interest to pursue and untutored ability to plumb. Millar (1975) reported that some blind children of elementary-school age could make raised-line drawings of people similar to drawings by sighted children. Millar recommended training blind children to draw. The recognition studies suggest, however, that there may be substantial untutored pictorial abilities present in the blind before any explicit training in depiction. How might these abilities manifest themselves in drawing tasks? A number of BOOST adults who had participated in picture recognition studies agreed to participate in drawing studies aimed at answering this question.

To begin with a subject that is universal, we asked some of the BOOST adults to draw a hand. The fingers of a hand can be drawn in outline sketches in either of two ways. Each finger can be shown by a single straight line, in which case the line is being used in stick-figure style. Alternatively, each finger can be drawn with a line showing the occluding boundary of the finger. Both kinds of drawings were produced by the volunteers. Thirteen adults

were tested (see table 4.1). Of the thirteen, four drew stick-figure fingers (see fig. 4.1a and c) and nine drew occluding bounds (see fig. 4.1b).

We continued the hand-drawing task by requesting a drawing with overlap. The topic was one finger crossing over the other. The four adults who drew stick figures made one stick cross the other like an X. Their drawings gave no indication of which finger was on top and which one below. Hence, it is not certain how the X functions. There were no spontaneous comments on ambiguity or alternative impressions. All that can be said for certain is that the X is taken by the blind to suggest one elongated thing on top of the other. The nine who used lines for the occluding bounds of fingers responded to the overlap task by drawing the occluding bounds of both fingers in their entirety (fig. 4.1b). The result includes four X junctions. To the eye it looks like a drawing where one finger is transparent. This kind of drawing has been called "X-ray style." It is found for example in Australian aboriginal art.

A third task was given to the nine volunteers who had produced the transparency drawings. The aim of the task was to invite use of T Junctions where the stem stands for a background surface occluded by the foreground surface delimited by the crossbar of the T. The volunteers were asked to show in their drawings which finger was on top. Five said that they did not know how. Four engaged the interviewer in discussion, seemingly in search of a solution, indicating they did not know it immediately. They asked, for instance, how a sighted person would solve the problem and what was meant by "one finger on top of the other." In responding, the interviewer attempted to leave the subject to his or her own devices and to be as nondirective as possible. But to avoid all guidance was impossible. To describe what was meant by "on top" we said that the top one was visible, the one underneath not. This was enough for Dee (early, totally blind) and May (early, totally blind) to realize that one could omit lines from X junctions to indicate by T

TABLE 4.1
Volunteers from BOOST who drew hands.

Onset of Blindness and Degree of Loss	Participants
Early (0-2 years), totally blind	Dee (2 drawings, after comment), Lys (2, upon request), May (2, req), Pal (2, req), Pau (2, req)
Early, light perception	Joan (2, spontaneous), Nip (1)
Early, low vision	Dot (1)
Late, totally blind	Mik (1), Ray (2, spont)
Late, low vision	Jon (3, spont)

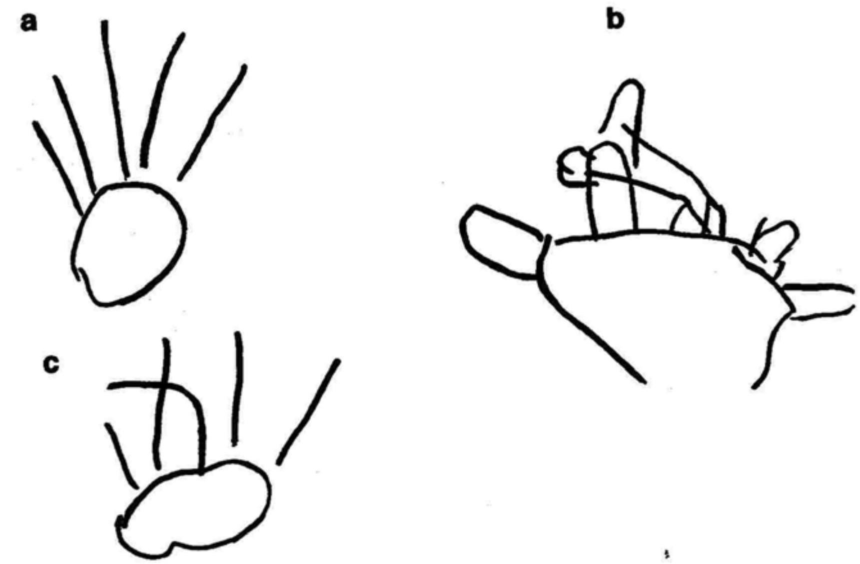

Fig. 4.1. Drawings of hands by blind adults in Toronto.

junctions which surface was on top. Ray (late, totally blind) reached the same solution without hearing a definition of “on top.” The drawings by Dee, May, and Ray are shown in figure 4.2. Arm (late, totally blind) would have had considerable experience with overlap drawings before age 11. It was no surprise that in her drawing she indicated overlap by omitting lines. She was likely relying on memory, not displaying original problem solving. More originality can be claimed for Dee and May; Ray's drawing was reached by the most independent route.

Fig. 4.2. Drawings showing one finger on top of another, by Dee (early, totally blind), May (early, totally blind), and Ray (late, totally blind).

DRAWINGS OF A GLASS

The second drawing task for BOOST volunteers was a container, the obverse of a solid object. Containers are about as universal as hands, and any powerful drawing system must cope with them. Yet containers create several difficulties for depiction and raise questions about haptic perception of occluding bounds. How can one show an exterior surface with occluding bounds and an interior hollow? In the case of a cylinder, how can a flat picture show a form that is round in one cross-section and rectangular in another at right angles? Do the blind acknowledge these difficulties spontaneously?

We gave our volunteers (see table 4.2) a flat-bottomed glass and asked them to draw it. Presumably most if not all cultures have perfected the knack of putting a flat bottom on containers so they can stand without support. If so, the universal container has edges at the top (the lip of the glass) and probably comers at the bottom (where the sides meet the flat bottom). It has occluding boundaries given by the sides, marking the distinction between the visible front and hidden back from any vantage point to one side of the container. When we grasp a cylindrical container there is no sharp boundary between the front and the back. Hence, one might expect that the blind would find the occluding bounds of a cylinder unsuitable for outline drawing. Alternatively they might use the notion of a vantage point and occluding bounds of a container readily, as they did in drawing the occluding bounds of a solid object, namely fingers.

Three of our volunteers began thoughtfully by explicitly noting that there was more than one way to draw a tumbler. Five others drew more than one glass when asked to do so after their first attempts and their comments. Three

TABLE 4.2
Volunteers from BOOST who drew a flat-bottomed tumbler.

Onset of Blindness and Degree of Loss	Participants
Early (0-2 years), totally blind	Dee (2 drawings, after comment), Lys (2, upon request), May (2, req), Pal (2, req), Pau (2, req)
Early, light perception	Joan (2, spontaneous), Nip (1)
Early, low vision	Dot (1)
Late, totally blind	Mik (1), Ray (2, spont)
Late. low vision	Ton (3. Spont)

drew only one glass. The three who indicated initially that they would make more than one drawing were Ray (late, totally blind), Joan (early; light perception), and Jon (late, low vision). Ray and Joan are of special interest since neither had had enough vision to use pictures.

Ray began by saying, "I'll do it this way first, then I'll draw it another way." He drew a rectangle and remarked, "This could be a glass from a certain angle but [it] doesn't show roundness." He noted further, "Could add lines." He proceeded to draw two lines across the rectangle-lines that were thick in the middle and thin at the side (fig. 4.3). In his comments Ray's grasp of the vantage point was clear and explicit. Furthermore, his device of varying line thickness has aspects of perspective about it. He went on to draw the glass "from the top," as he put it, which involved drawing two concentric circles. The inner line is the "inside perimeter," he noted, and the outer line is the "outside perimeter." The perimeter presumably is the inner and outer surface of the wall of the glass "from the top," as Ray said. He added intriguingly; "Be interesting to draw some pictures from different perspectives and see if people can figure out what it is!"

Ray's grasp of aspects of vantage points is lucid, and he explains his ideas well. One interesting possibility is that although Ray is unusually precise and clear in his explanations, his ideas about perspective are shared by many blind people. Alternatively; Ray's fine logical mind may allow him to arrive at ideas during our interview, ideas he was not using prior to the test and ideas very few blind people would use ordinarily. Moreover, Ray; despite his severely limited visual experience, may be basing his ideas on visual memories. To test these alternatives requires research with blind people of various ages, at a range of educational attainments. Ray's drawings and comments raise profound questions about perspective which cannot be settled on the basis of a single case. Shortly I will describe several experiments, with several groups of

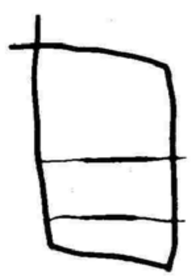

Fig. 4.3. Drawing by Ray (late, totally blind) of a glass, with lines becoming thinner to indicate the roundness.

early and late blind volunteers, and compare different ways matters of perspective can arise in the tactile domain.

Joan also remarked that more than one drawing would be appropriate. She was given a glass, and as she held it and explored it manually she began to speak haltingly; "If the glass is open..." After a pause she went on, "I'll demonstrate my question by drawing two glasses, in different ways." Her first drawing was a single line, a rough U shape with a flat bottom. She said, "I've left the top open because a glass is open at the top." Her second drawing showed each side and the bottom by two lines parallel and close together. Then she added a single line across the top and said, "The single line on top shows it's still open" (figure 4.4).

We might call Joan's first glass a stick-figure glass in cross-section. One line, substituting for the thick wall of the glass, shows a referent with two surfaces. In the second, one line is used for each surface of the glass. Hence, a line can be used for the top surface-the lip or edge--of the glass. In the first drawing, though, the lip can be omitted since it does not have two surfaces. Notice that
Joan, unlike Ray; never mentioned a vantage point. Her discussion was restricted to the parts of the glass. She never said, for example, that the inner surface would only be facing a vantage point if the glass were cut open or cross-sectioned. There is an important contrast between Ray's explicit use of "perspectives" or vantage points and Joan's way of drawing most shapes. Joan's glass can be described almost entirely as matching parts of the drawing to features of the glass in a geometry of similarities, treating the glass as an object independent of anyone's vantage point. The shapes of each part of the, glass are repeated, in Joan's style, as shapes made of lines. One exception is

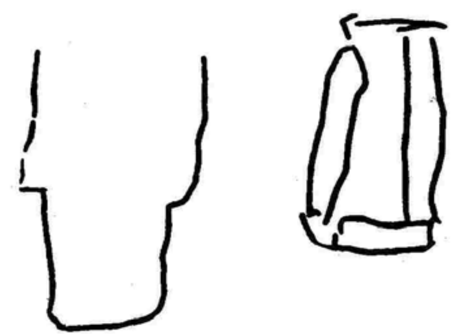

Fig. 4.4. Drawings by Joan *(early,* light perception) of a glass. The one on the left, leaves the top open. The one on the right uses a single line to indicate the lip of the glass and double lines for the walls and base of the glass.

the single line for me lip of me glass. This is a straight line, though it is only straight as a projection to the side.

We encouraged four of the early, totally blind informants to try showing the roundness of the glass. The fifth early, totally blind subject (Dee) brought up the matter herself. Dee's drawings are in figure 4.5.

Dee began with a U shape with a flat base. Her comment was, "But it doesn't show the roundness of it, only how the sides come down and the bottom. It could be a number of things." For her second version she drew a U shape with a flat base but added an ellipse to the top. She commented, "But this would be confusing to someone else--the flatness of it. It's only in two dimensions. I don't think someone would think of it as a glass." Dee's ellipse likely is meant very generally as a rounded form, with no perspective effect intended.

Consider now drawings by Lys (fig, 4.6). Lys's glasses are like Dee's in many ways, though the process leading to her drawings was different. Lys began with the rounded shapes for the top and bottom. Then she added a single line, from top to bottom, linking the rounded shapes and running through the middle of the drawing. We asked her to explain. A glass "has a rounded top and bottom and comes straight down," she said. Lys's single line for "straight down" is not a line standing for an occluding edge or comer. It is not in outline style. It shows that the top and bottom of the glass are connected by a surface extending from one to the other. It does not show the left and right boundaries of the connecting surface; rather, it shows the surface's nearest part. One might jump to the conclusion that the straight-down line, and the absence of lines representing the sides of the glass, can be taken to indicate that Lys does not readily understand that lines can stand for rounded bounds of objects. Fortunately, in the interview she was asked if there was any way to show the sides of the glass. Right away she drew two parallel lines joining the extreme left and right portions of her rounded

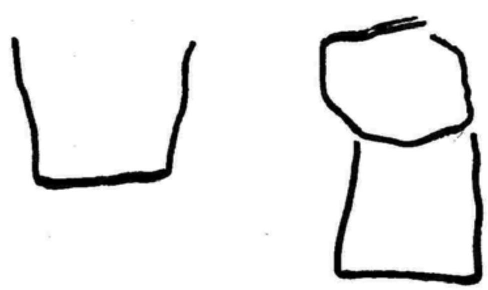

Fig. 4.5. Drawings of a glass by Dee (early, totally blind).

Fig. 4.6. Drawing of a glass by Lys (early, totally blind).

shapes. Evidently, she understood that lines could stand for rounded boundaries of objects without difficulty.

Next, Lys spontaneously drew the glass as a rectangle, saying that this was like the tree trunk in the elephant story which she had explored some minutes before. We asked her about the roundness at the top and bottom of a glass. Promptly she drew two circles (fig. 4.7).

Josiane Caron-Pargue (1985) studied sighted children drawing cylinders. She describes the children as "disintegrating" a cylinder into a rectangle and circles (p. 239). Their drawings comprise combinations of these two forms--"core" shapes, as Goodnow (1977, p. 143) puts it. Sometimes the drawing contains a full rectangle but only half-circles at top and bottom. Caron-Pargue considers this as emphasizing the rectangle. Sometimes the drawing includes two full circles but only two parallel lines join them. Caron-Pargue describes this as emphasizing the circles and correspondingly deemphasizing the rect-angle. Both the rectangle and the circles are present in the cylinder as shapes of parts of the object. The artist, then, selects from among these features in making a drawing of the object. The selection process need not involve a vantage point. For the flat surfaces of the object, volunteers may have envis-aged partial imprints. For rounded surfaces, they may have considered cross

Fig. 4.7. Drawing of a glass by Lys (early. totally blind).

sections or the shapes of some of the outer surfaces of the object, following a similarity geometry.

In the terms used by Caron-Pargue, Dee emphasized the rectangle present in a glass, by drawing three sides of the rectangle at the outset, and secondarily copied the curved shape of the top of the glass. Lys in her first drawing emphasized the circles, adding only parts of a rectangle and making the addition only after being asked a pointed question. It is instructive that Lys and Dee made drawings on their first attempt that are similar to drawings by sighted children ages 7-9 studied by Caron-Pargue, although the sighted children have had much prior experience interpreting and drawing pictures.

Joan, Dee, and Lys failed to make explicit mention of a vantage point. In this they were unlike Ray. When Ray selected parts, he was guided by a vantage point both in the selection itself and in arranging the parts on the page. Ray considered the *direction* of parts from the vantage point. He did not draw both circles and a rectangle, only one or the other, since the circular parts of the cup face one vantage point and the rectangular parts face others. Ray never drew a line like Lys's single line for "straight down"; he only drew boundaries of the object from a vantage point. His lines denote comers and occlusions whereas Lys'S straight-down line denotes how the object is ex

tended, a very general aspect of surface layout since it belittles the shapes of me margins of a surface. It is too general to distinguish comers from edges, or either of these from curves or cracks. It indicates the orientation of the most extended dimension of the object (Willats, 1989). Lys's straight-down line is probably less sophisticated than lines for surface relief change.

May (early, totally blind) and Pau (early, totally blind) introduced a third method of solving the drawing problems set by a cylindrical container. May and Pau transformed the shapes used to show parts of the glass. May drew the glass initially with a U shape, including a rounded base, and added a handle. Then, after she was asked to think of another way to draw the glass, she drew a flat base instead of a rounded base but made the sides curve instead of being straight (fig. 4.8). Pau first drew a rectangle; then, when we asked him if he could show that the glass was round, he drew a more circular shape, saying, "I tried to make the lines rounder. The first one looks more like a door. It's square" (fig. 4.9).

May and Pau modified the shapes they had used to show certain parts of the object in order to show shapes of other parts. There is an instructive difference between the explanations for shape modifications from May or Pau and comments, for example, on change of shape from Pat (early, totally blind). Pat drew a rectangle for the glass initially. When she was asked if she could show the roundness, she drew a wide, shallow, rounded U; she said that the top was deliberately wide and that "this is a different kind of tumbler." When Pat changed the shape on the page to show a rounded container, she acknowledged that it suggested a differently shaped container from a glass with parallel sides. May/and Pau achieved both of the conflicting aims by allowing their shapes to change, thereby producing a compromise image. Within the limits that they acknowledge of the medium (Arnheim, 1974), they try to

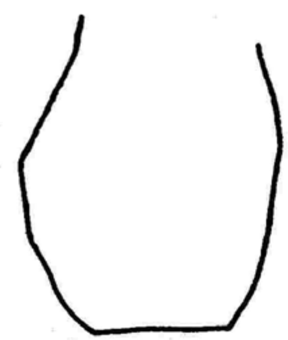

Fig. 4.8. Drawing of a glass by May (early. totally blind).

Fig. 4.9. Drawing of a glass by Pau (early, totally blind).

depict two contradictory functions with one representational unit. This is double entendre in language, and in depiction the equivalent might be called a pictorial pun.

The tumbler drawings reveal several ways to achieve pictorial ends. They show that the blind have no difficulty accepting a line as a boundary for a rounded object. Straight lines are used frequently to depict occluding bounds of cylindrical shapes. Junctions with L shapes may represent, for example, the rounded sides of the glass meeting the flat base. An explicit vantage point is occasionally used to select the shape for depicting a solid object, and the limits of the depiction are noted. Attempts to overcome the limits lead to some devices incorporating perspective (thickness of line) or context (such as a handle of the glass) or a compromise like a pun (depicting straight sides by round lines relevant to a neighboring feature).

DRAWINGS OF A TABLE

A third task we set for BOOST volunteers was to draw a table. A table consists of a surface that is horizontal and legs that are vertical, meeting the surface at its comers. It requires the solution of pictorial problems of the most profound kind. Surfaces that are at right angles have to be shown. I chose a table as an object exemplifying three dimensions, because it is comparatively familiar to people of all ages and likely to be found immediately in most cultures. A picture of a table can aim to show shapes of the supporting surface, as well as its edges, thickness, and orientation. It can show some or all of the legs, their connection to the horizontal surface, their shape, and their orientation. But not all the features of a table can be drawn in a single picture. Some have to be sacrificed. What guides the selection of some features and the elimination of others? What role do similarity geometry and vantage points play?

Though a picture is flat, it has many dimensions one can vary. That is, a picture, unlike a scale model, cannot replicate a three-dimensional scene, but it can include many kinds of arrangements. In mastering depiction the artist

may select as relevant more and more aspects of the arrangements of lines on a surface. A novel, like a picture, is printed on flat paper, but it can be rich in dimensions of variation in style, elements, characterization, and arrangement or plot. It behooves the interpreter of novels or drawings to determine which modifications of the elements (Goodnow, 1977, p. 123) are being selected to stand for features of the world.

Pictures can be flat and thus two-dimensional in spatial extent but still multidimensional in other respects. A case in point is. a video game that exploits relationships within the flat video screen to create the impression of depth. An airplane shape appears fixed in the center of the screen, pointing upward. The pattern on the screen around the airplane scrolls downward to suggest that the airplane is in motion. The terrain the airplane flies over is sometimes mountainous and sometimes level. The airplane has to rise high above the plain to be sure to avoid crashing into the first mountains it encounters. To indicate height, a black copy of the airplane simulates its shadow, moving close to the airplane when it is hugging the ground and receding from the airplane when it rises high into the sky. The distance between the airplane and its shadow on the screen is a dimension of variation within a two-dimensional surface that is information for depth.

In principle, flat surfaces can have many informative dimensions of variation. The top of the page can mean something different from the bottom. The diagonal can mean something different from the horizontal or vertical. The picture can involve special informative features such as parallels, space between lines, connections, angles between lines, straightness, curvature, and closed or open shapes (circles versus C shapes), and the features indicated by elements such as lines can change over time. An outline drawing from a vantage point employs many of these features. It incorporates many dimensions of variation. Indeed, a picture offers as many possible dimensions of variation as a section of the optic array. In depiction, as in nature, there are many informative variables. Optic arrays vary in ways related to arrangements of objects in depth. Perceptual systems, in tom, become sensitive to the variations and, in some cases, take them as the basis for perception of depth. Likewise, people making pictures employ some of the possible dimensions of variation in the picture surface to represent other variations in the real object. Which dimensions, one wonders, will seem pertinent to the blind person? What will show the shapes given by a table, an object that extends horizontally and vertically?

Nine volunteers from BOOST (table 4.3) attempted tasks involving depiction of a table. The volunteers devised quite diverse drawing systems.

Two of the volunteers, Ray (late, totally blind) and Dot (early, low vision), began with the comment that there is more than one way to draw a table. Dot

TABLE 4.3
Volunteers from BOOST who drew tables. A star table is a rectangle with four lines radiating one from each comer.

Onset of Blindness and Degree of Loss	Participants
Early (0-2 years), totally blind	Dee (star), Lys, May (star), Pal, Pat
Early, light perception	Nip
Early, low vision	Dot
Late, totally blind	Ray (star), Ely

had had many years of useful though very limited vision, and so Ray is the most important informant regarding the effects of blindness. Since Ray never had sufficient form perception to see a picture, his performance was impressive (fig. 4.10).

Ray said, "If you're looking straight down, you'd draw a rectangle without legs, because you won't see them." He proceeded to draw a rectangle. Next, he said "If you drew it directly from the side, you'd only see two legs--a rectangle with two legs." He then drew a rectangle with two straight appendages coming down the page. His third drawing was ingenious. He drew a rectangle with four appendages, each one radiating from a comer of the rectangle. He said, "But to see it this way, you'd have to be under the table."

Ray's three drawings of a table are an intellectual feat of some note. In brief sentences and apt drawings he summarized and applied lessons of perspective that were mastered by visual artists only in the Renaissance. His examples are chosen well and produced more adequately than I would have dared believe possible before this research was undertaken. His skill is admirable, not only for someone drawing without sight but also for anyone inexperienced in drawing, and with little experience of pictures. Indeed, each of his drawings is an excellent fit to the different vantage points he wished to demonstrate. His third table drawing, with legs radiating like a star, is a remarkable application of a vantage point. His choice of an unusual vantage point allows all of the parts of the table to be displayed, as well as the shape of the tabletop, the symmetrical placement of the legs, the straightness of the legs, and their connections with the tabletop comers. No part of the table obscures any other part.

Ray's drawings are particularly clever. But each of the features that his drawings display is present in drawings by other blind informants, including

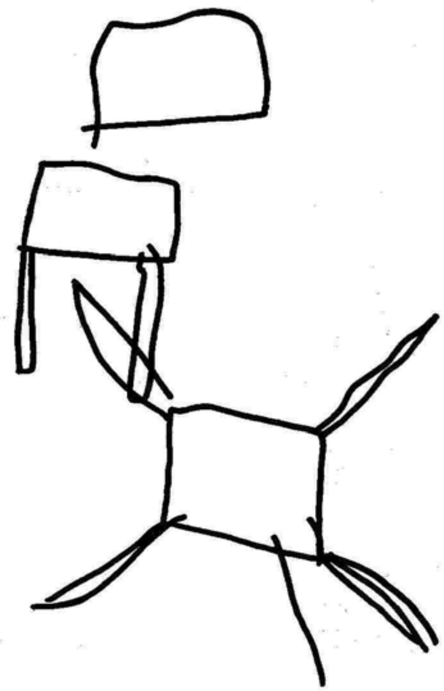

Fig. 4.10. Drawings of a table by Ray (late, totally blind). The top form is a table from above, the middle form is a table from the side, and the lower star-like form is a table from underneath.

his use of vantage points. Pat initially drew a rectangle with two appendages and said, "It has four legs but just two are showing" (fig. 4.11). Later she added the two "inner" legs. Shortly after, she made a similar drawing and said about the two legs not drawn, "They would be behind these two, obscured." Lys, Pau, Nip, and Dot each drew a table in an inverted U shape, like a rectangle without the bottom line. This can be described as a table from the side, with the horizontal line indicating the near edge or side surface of the tabletop.

The most common table drawing from the blind volunteers was a rectangle 'With four appendages. Everyone produced this pattern at least once. But it was the product of two different drawing systems. Ray used vantage point to produce the drawing. None of the others who drew this pattern mentioned a Vantage point. Both Dee (early, totally blind) and May (early, totally blind) drew a table with its legs radiating in a star, like Ray's, but neither mention a vantage point. Nip (early, light perception) had the four appendages to the

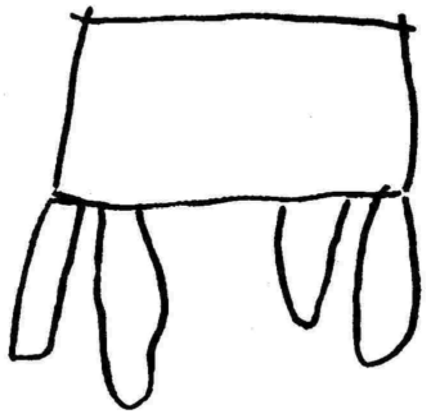

Fig. 4.11. Drawing of a table by Pat (early, totally blind). Initially, only two legs were drawn.

central rectangle emerge two to one side and two to the opposite side. He said "I can't put the four legs down, so two have to go up." Two legs go down, matching the direction of table legs by a direction on the picture surface, but the other legs are drawn in ways that avoid putting the table legs and the table surface in one region in the picture surface. Goodnow (1977, p. 34) notes that sighted children ages 7-10 use the same rule. Lys (early, totally blind) draws two legs" coming down" and then two back legs, one going to the left and one going to the right. All the legs are at right angles to the table sides. Dee drew a second table where the rear legs meet the sides of the rectangle at about 30°, to show that all the legs come "down"; her choice of an acute angle allowed her to draw the legs without their running into the sides of the rectangle.

Evidently, two kinds of drawing systems need to be described. In one, the deployment of parts shows their directions from a vantage point. In the other, the deployment of parts is to match the features of the table, but not their direction from a vantage point. Legs "come down" or are "at right angles" to the table surface or radiate symmetrically "from the comers." Placement can be modified to avoid juxtapositions on the picture surface that are deemed to be unfortunate or prohibited, a principle that sighted children use (Goodnow, 1977, pp. 43-44).

The seven BOOST volunteers who had never had appreciable form perception were asked to complete two perspective drawings of a tabletop. One drawing was a trapezoid and the other was a rhomboid. The task was to add the legs. The rhomboid (fig. 4.12) could betaken to be a picture of a

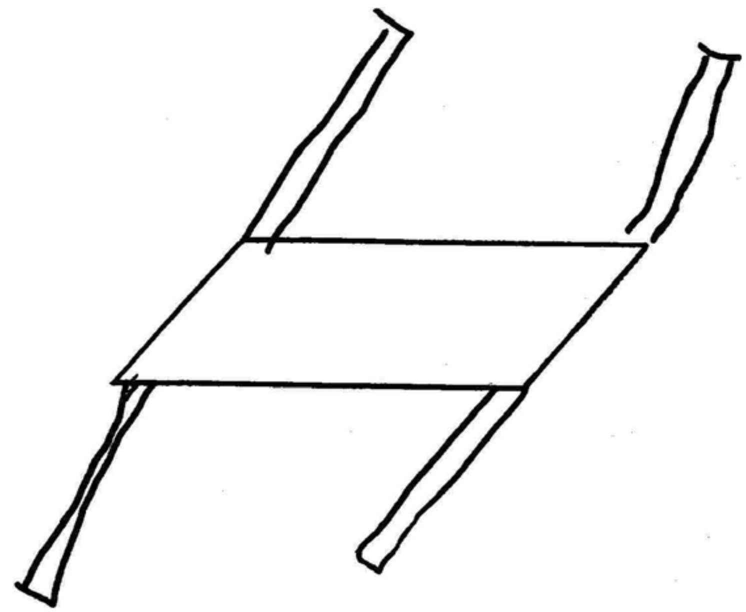

Fig. 4.12. Using a rhomboid to make a drawing of a table, by Ray (late, totally blind).

rectangular surface in oblique projection, with oblique parallels indicating parallel sides of the table receding into depth. The trapezoid could be taken to be a rectangle shown in convergent perspective.

All but one of the volunteers considered the rhomboid and the trapezoid to show the shapes of unusual tabletops, such as comer tables or some kind of stacking tables that fit together. That is, the shape on the picture surface generally was taken to be the shape of the table surface. Only one person, Ray, made a comment that might indicate an understanding that a tabletop's rectangular shape taken together with directions from a vantage point could produce a nonrectangular shape on the picture surface. Ray commented when examining the rhomboid, "I don't know if it's actually this shape or it's perceived in this shape. "We told Ray the table top was not actually this shape. He then said, "So its seen from an angle." He went on, "In keeping with the shape of it, you have to put legs on this way," and he proceeded to draw legs that continue the direction of the short, parallel sides (fig. 4.12). Presumably he thought that viewing on an angle produces a shape for the top of the table that will also be produced for the legs of the table. He was unable to anticipate that the legs, in one plane, can be affected differently from the tabletop, in a different plane, by the choice of vantage point and projection from it. He failed to intuit how oblique projection works.

Important limits to drawing skills in the blind may be inferred from the table study. Notions of vantage points were used by a number of the volunteers. But in every case where a vantage point was made explicit, the shape drawn on the page was similar to a shape in the referent. The tabletop, for example, was shown as a rectangle. None of the informants ever drew a shape different from that of the referent, as would result from considering the shape from a certain vantage point. They did not describe how the set of directions from a vantage point is preserved while the shape departs from similarity. Oblique projection does not come readily to the blind.

The table drawings corroborate the finding that lines can stand for occluding edges of flat-surfaced objects for the blind. Furthermore, sometimes two lines were used for a table leg, sometimes one, as occurred in drawings of fingers on a hand. The drawings often involve T vertices to show table legs meeting the edges of the table, and Y vertices showing the legs meeting the comers of the table. The arrangement of lines and vertices is governed at times by a vantage point system that maintains rectangular shapes. Frequently the system respects the connections between parts but treats the angles at vertices as a matter of convenience, as though the legs were folded out in whatever manner--up, down, sideways--was convenient to show all the legs without crossing into the space representing the tabletop. Shapes of distinct parts such as the legs and the tabletop are respected, and the connections are almost always preserved intact, but the angles formed by the parts at the connections are highly variable.

DRAWINGS OF THE VOLUNTEER'S CHOICE

In an attempt to broaden the inquiry and to loosen the rein on the volunteers' skills, we asked the BOOST adults to make drawings of their own choice. We suggested that they include drawings of things they had not had as miniature models, like toy houses and cars. We mentioned that they had probably not had model bathtubs or filing cabinets.

Eight BOOST members volunteered drawings (see table 4.4). Some of the volunteers adopted our suggestions. A bathtub from Lys (early, totally blind) shows the rectangular shape of the bathtub, the depth by means of arcs from the comers of the rectangle, which presumably suggest a kind of concave comer, and, in Lys's terms, "two little circles at the top end to put things on"

TABLE 4.4
Volunteers from BOOST who drew objects they themselves selected.

Onset of Blindness and Degree of Loss	Participants
Early (0-2 years), totally blind	Dee (filing cabinet, chair)
	Lys (bathtub)
	May (filing cabinet, bathtub)
	Pat (duck's foot, bathtub, gothic door, illustrations for a fairy story)
	Pau (sun, airplane wing, smoking chimney, drawbridge)
Late, totally blind	Joan (dog standing, dog lying down)
	Mik (filing cabinet)
Late, low vision	Jon (filing cabinet)

(fig. 4.13a). May (early, totally blind) showed the shape of the bathtub (fig. 4.13b), with a faucet (one end open) and two taps with ridges 'With which to grip the taps. She also drew a filing cabinet with two small drawer fronts and one large drawer front. Dee (early, totally blind) drew a filing cabinet and a chair with slats in the backrest (fig. 4.14). These drawings involve outlines showing occlusions and comers.

Joan (early, light perception) drew her guide dog twice, once depicting it standing up and once lying down. She said of the standing dog, "Do I draw two legs or four legs? Two legs, because I'm only drawing the side." She was frustrated with her drawing of the dog's head: "I don't know where the ears and nose and mouth go!" She left her first drawing of a dog unfinished, as she put it. Joan's difficulty depicting the dog's head is deeply instructive. She is perfectly familiar, in many respects, with the dog, and she can produce drawings of glasses and hands that she finds satisfactory and that appear competent to the eye. Her difficulties with the dog's head appear similar to ones reported by Critchley (1953) and others in studies of the blind. The root of the trouble, however, is probably not a matter of blindness, for the sighted encounter it as well. Most sighted people cannot draw a dog's head so that it can be distinguished from a horse's head or a squirrel's head. My own drawings of parts of an animal such as a dog's head or a horse's leg are, frankly, appallingly nondescript. My horse's legs make the horse look like it is wearing pajamas. By contrast, there is something about tables, hands, and glasses that makes a

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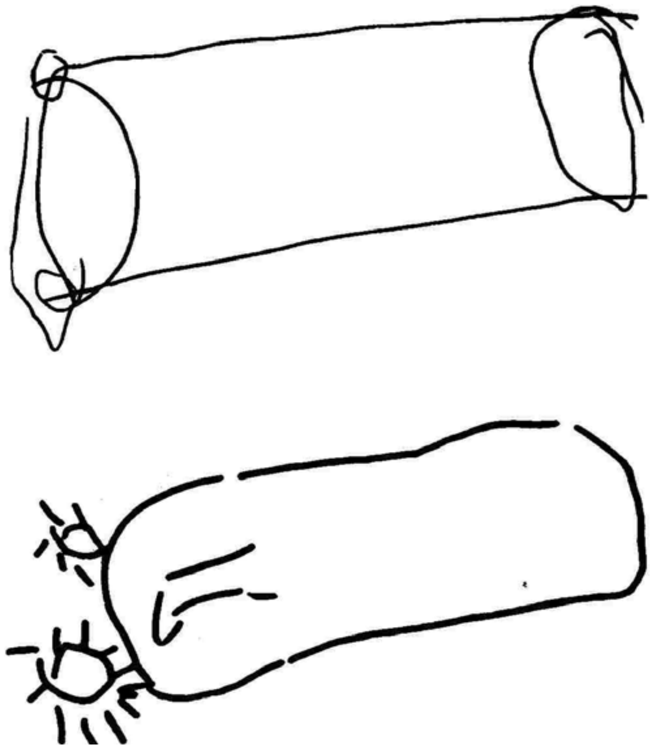

Fig. 4.13. Drawings of a bathtub, by Lys (early, totally blind) and May (early, totally blind).

drawing them distinctively rather facile. That gap in depictability is likely determined by the number of features, the need for correct proportions (especially of curves), and the failure in most observers to have explicit knowledge of key relations, such as the shape of a dog's brow and a horse's fetlock, that distinguish these from analogous features in other animals or rag doll animals. If we try to draw a dog's nose-to-mouth line as prominently curved, like that of a human face, and a horse's rear leg as bending forward, like a human knee, we fail to draw the shapes of these features correctly. We know each of them tacitly, but not explicitly, until we attend to them. That failure to know familiar shapes explicitly is shared by blind and sighted observers, it seems. Although we may be able to call to our minds a tolerable image of a horse, that does not mean we can access the knowledge in the image to correct our drawing. Usually all we can say is that there is something wrong with the drawing of the rear leg or the head.

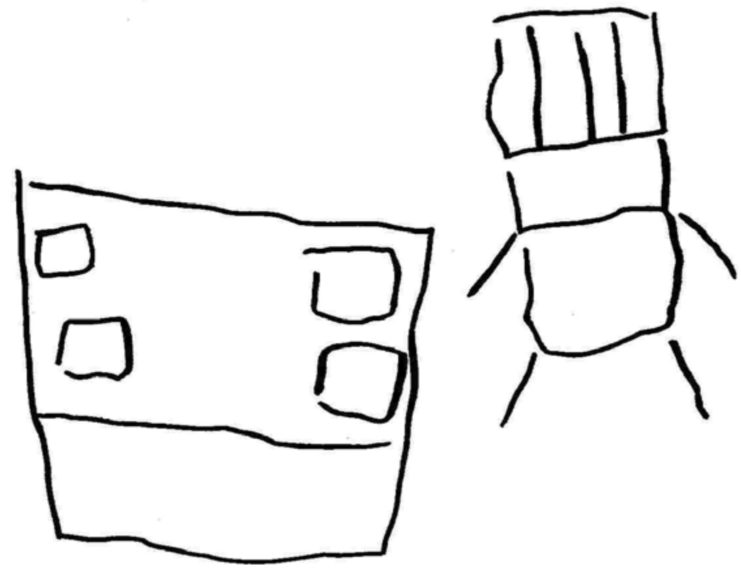

Fig. 4.14. Drawings of a chair and a filing cabinet, by Dee (early, totally blind).

Pat (early, totally blind) produced some revealing drawings. They include a bathtub and two illustrations for a fairy story (fig. 4.15). The bathtub is shown with a person standing outside it. Between two taps at the end of the bathtub is a faucet with a stream of water coming from it. Pat also drew a picture of a princess outside a castle, showing the door of the castle, a turret with a pole, and "a little spiky tree." To contrast with the spiky tree Pat also drew a bush, showing its overall configuration rather than individual branches. Another drawing shows the princess, in stick-figure style, sitting on a chair (shown from the side) by a spinning wheel. Inside the spinning wheel there is a "line of motion," and the wheel's perimeter is doubled. Both the stick-figure version of the person on the chair and the devices indicating motion are economical and intriguing uses of line. The stick figure uses lines as axes of bodies. The spinning wheel uses a line for something that is not an edge or occlusion. (I shall discuss its status later.) For a novice, Pat makes very competent use of line drawing. These drawings would do credit to sighted children of early school age. They indicate that a blind adult can draw competently using raised-line drawing materials after only a few moments' practice with the materials, and without having to experience stages like making scribbles or unrecognizable patterns.

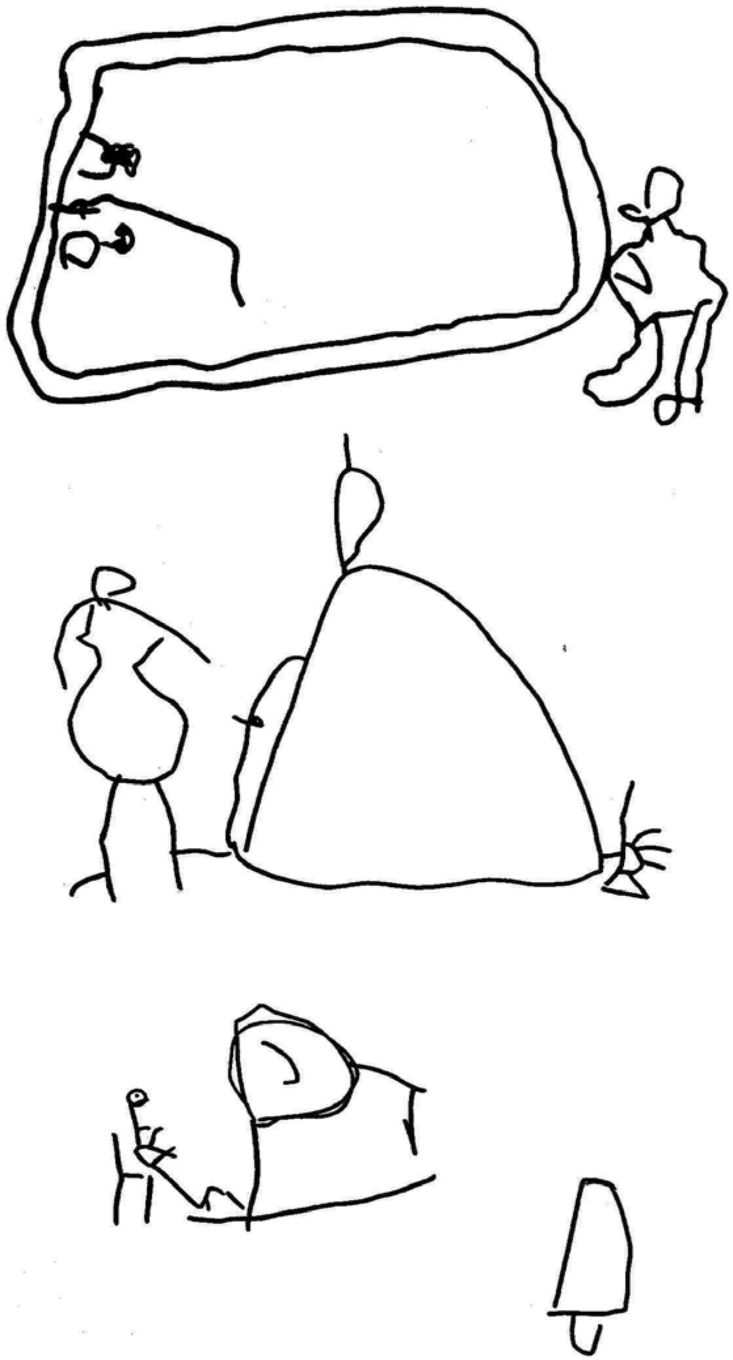

Fig. 4.15. Drawings by Pat (early; totally blind) of a bathtub with a person standing beside it, a princess beside a castle, a princess working a spinning wheel, and a bush. A curved line shows the movement of the wheel.

Tracy

I asked Tracy; an adult blind woman, to make a wide variety of drawings. Tracy lost her sight at age two (close to 24 months) as a result of an operation for retinal blastoma. At age 28, when she drew for me, she was totally blind. Tracy comes from a family with strong arts interests. Her parents are involved with dance, and both parents have training in graphic design. Tracy herself has taken an interest in drawing with raised materials. Her family has encouraged her, praising her drawings, but has not taught her. She has also tried to "figure out" printed outline drawings using an Optacon Scanner. The scanner makes a pattern on the fingertip pad by means of small vibrating rods, copying the pattern under a small window (about fingertip size) in the scanner's wand. Tracy says she can "figure out" simple print pictures sum as a silhouette of a seagull. She describes her drawing as largely self-taught. She notes that she makes raised pictures of such objects as her dog or a plastic model of an animal, then checks her picture against the original and corrects her picture, repeating the process until she is satisfied. In her deliberate use of this cyclical procedure Tracy shows a clearer appreciation of methods for improving one's drawing than most sighted people have, who often draw once, then simply confess failure to achieve the ends they had in mind.

Figure 4.16 reproduces some of Tracy's drawings. Included are a glass, a cat, a mouse, a head, a man standing, and a man lying down. The drawing of a glass repeats the pattern used by BOOST adults. I asked Tracy what the lines, stood for and she ran her finger along the left occluding bound of the glass itself, across the bottom, and up the right side. When I asked her whether the lines could stand for another aspect of the glass, namely, the front, bottom, and rear, she said no. She reasoned that her drawing resembles the drawing one would get by laying the glass on the drawing surface, then running a pencil along the sides of the glass with its point resting on the drawing surface. Her words were, *"If* you laid this glass down *[she did so]* and drew around it *[she gestured so]* you'd get this *[her drawing of a glass as a U-shape]* but not across the top and not down the insides." This is a mechanical procedure that produces parallel projection. It reproduces a shape on a surface because it projects from a direction. Tracy was demonstrating by her procedure the kind of manipulation of space that resulted in Ray's tables and Joan's and Ray's glasses. Other cat drawing she said, "That's my cat. He is a seated cat with his tail wrapped around his back feet. A pretty fat cat. He is looking at whoever is looking at him." I asked her where she got the idea from--a stuffed cat? "No, we have a real cat who sits around like this."

I asked Tracy to draw a man in profile. The head came too close to the top of the page so she redrew it, enlarging it. The main axis of the standing figure

Fig. 4.16. Drawings by Tracy (totally blind, sight lost at age two) of a glass, a cat, a mouse, a man lying down, a man standing, and a head.

is vertical on the page, that *is,* the feet are close to the person drawing when the page *is* flat on the supporting desk surface, and the head *is* farther away. This *is* taken to mean "standing," although the page *is* actually parallel to the floor. In these terms, the axis of the picture surface at right angles to the page vertical *is* to be described as horizontal. I asked her to draw a man lying down. Her drawing began with the legs, which she showed bent at the knee to indicate by his posture that he was reclining. The arms are shown over "the belly," she said. The use of the bent knees *is* astute as a way of showing that

the man *is* lying down, as an addition to the horizontal main axis of the figure. Tracy's drawings recapitulate the lesson learned from picture-identification studies with BOOST subjects of a man standing or lying down (see chapter 3).

Tracy mentioned that she had once heard someone on radio discussing Walt Disney. Mickey Mouse, it was said, had been drawn economically using circles for the ears, head, and other body parts. Tracy had devised a drawing of a mouse based on these principles and wanted to show it. Her mouse sketch includes circles for the ears, the head, and the paws. The body *is* an oval, and other features are added to these simple forms. Tracy called this her Mickey Mouse drawing.

Tracy showed skill in visually depicting stereotypes. Stereotypes are a set of forms that can be readily repeated so that successive drawings have only minor variations. Wilson and Wilson (1982a, 1982b) report that many sighted children's drawings have this character. Tracy appears to have invented many of her own stereotypes based on experience with model figures, as well as real objects, and hearsay about simple bases for analyzing forms into parts. In principle, all forms can be analyzed into circles or cubes. They can be made of flat planes or building blocks or strips--hence the success of Meccano and Lego. Tracy seems to have heard about analysis into circles and applied the idea. Her man figures appear to be based on a conception of a posture and on knowledge of details of joints, shapes of the calf, the chin, and other small components of the profile. She shows how practice in drawing and a knowledge of form can be applied by blind people to produce a sketch specific to a narrowly defined referent and its posture. It *is* comparatively easy in looking at Tracy's drawings to make out the object, its species, its posture, and the vantage point adopted.

Heller (1989), after a study of picture identification by early and late blind volunteers, responded to interest expressed by the participants in drawing with the kit he had used to make his raised-line drawings. Several of his adult subjects produced chairs in profile and tables with only two legs shown. Some produced what Heller terms an "aerial" vantage point on the chair. The back and two legs were drawn in profile, and the seat was drawn as a rectangle. An .early blind person drew a dog with all four legs shown. The posture was that of a dog rearing up on its hind legs. Heller mentions that many blind subjects spontaneously think of shapes in profile while attempting to decipher drawings. He notes that the blind subjects in his study were not familiar with picture perception or production. In Heller's report there are clear demonstrations of objects drawn from the side, as profiles, and from the front like a smile-face button. Lines are used as axes of extended bodies like a leg of a chair, for occluding bounds of a rounded object like a dog, and for occluding edges of the seat of a chair.

Sally

Pring (in press) reproduces drawings by Sally, an 11-year-old girl, totally blind since age 16 months. Sally was tested for intelligence, and both her verbal and performance scores rank within the top 2 percent for her age. She is successful in school. Pring tested her shortly after Sally had begun drawing using a raised-line drawing kit. Sally drew a cat, a woman, a train, a mountain, the sun, a telephone, a spider, and a tree. With the possible exception of the mountain, all of the drawings are immediately recognizable.

Sally was asked to describe her drawings as if for a visitor from outer space. She described a tree as "a shortish round cylinder [for the trunk, apparent at the bottom] with triangles, getting shorter as it goes up, like a pyramid." A wine glass, she said, was a flat round base with a cylindrical stick going up from it and curving out, ending in a slightly rounded box. Pring points out that these responses show Sally to be skillful at describing the spatial structure of objects. She does not describe parts in terms of their function, for example, the part the glass (or tree) stands on, the part you hold (or the part that holds the branches), and the part that contains liquid (or the part that takes the Christmas star).

Katz's Pupils

David Katz's (1946) long-overlooked study of drawings by blind adolescents (ages 12-18) contains several drawings that are instantly recognizable on sight. They include seven drawings of people, some as stick figures and some as filled-out spaces with such details as eyes, nose, and mouth. One pupil produced a detailed drawing of a bird from the side, showing a tail, a wing, two stick-figure legs and feet, a neck, an oval head, and a beak. Katz refers disparagingly to this drawing, saying he has never seen a drawing of a bird so hopelessly unskilled. He writes that the so-called body scheme that these adolescents drew is an utterly primitive representation of a man, and that even the best result of a 13-year-old blind child is not at the level one would expect from a six-year-old with intact vision. He notices grotesque proportions, and he suggests that when the children used individual lines for limbs the parts of the body are being reduced to stroke-like symbols without the least regard for their real form or their relative position. He demotes drawings by the blind to a lesser status, it seems, when he writes that the blind

always draw animals from the side. They show a "highly abstract attitude" that never occurs in the sighted, he says (translation by Costall and Vedeler, 1992).

Katz is perplexingly indifferent at some junctures to the skill his charges showed. The bird drawing has excellent proportions for a goose. The fact that a 13-year-old blind girl who is a novice at drawing is perhaps at the level of a five- or six-year-old sighted child in her first few attempts at drawing is astonishing, not an indication of a fault. No one should expect mastery to be acquired and demonstrated instantly. While some of the drawings by Katz's blind subjects show odd proportions, so too do drawings by sighted children. Katz also reproduces well-proportioned pictures of large objects, for example, a house (with such details as front-door steps). He reproduces several creditable drawings of small objects: a stick-figure drawing of a dog is unmistakably an animal and not to be confused with the stick-figure drawings of people. Katz is quite off the mark when he regards stick-figures as symbols without form or relative position. Drawing animals from the side is entirely appropriate, as many authors have pointed out, for from the side they reveal most of the features of proportion that distinguish one animal from another. To achieve the same end with insects, the common practice is to draw, them from above. Indeed, that is precisely what Linda Pring's student Sally did; Sally and Katz's pupils use stick-figure lines to show limbs of creatures. This is one of the appropriate uses of line, as much in keeping with the axis theory as lines standing for occluding bounds of the head or body. It is not a use that disregards the form of the object or the canons of outline drawing.

Katz's belittling comments may stem from his conception that drawing should not reveal an abstract attitude. What Katz means by this is unclear. He is certainly wrong in implying that sighted people do not draw in an abstract way. It is perfectly normal for a sighted person to sketch a room and squiggle something to show a plant of some kind in the comer. A squiggle can be an animal of some kind in a cage at a zoo, or a car of some kind in the driveway, or a tree of some kind at the end of a garden. I can make nothing of Katz's claim that blind children may draw "an animal of some kind" and sighted people never do. Fortunately, Katz did not halt there.

Katz invited his pupils to draw tables, cylinders, pyramids, and cubes. This is a remarkable anticipation of the choices of later experimenters! The selection reflects, I think, the attempts by independent investigators to present objects that are simple and well known but capture some of the key difficulties in moving from solid objects to pictorial surfaces. His findings were just as I have described here, following studies in North America and France. They are often drawn "folded-out," he notes, reporting that his pupils used phrases like "fold the sides upwards" about their drawings of cubes and pyramids. Katz then relents, it seems, and comments that the similarity with sighted children's drawings is striking. Alas, he fails to reach the conclusion that the principles sighted children employ as they advance will, with practice or suitable problems, be the principles the blind children will discover as *they* advance. Perspective drawing, he contends, will always have a flavor of artificiality as it must follow the laws and conditions of vision. Katz stresses that foldout principles are the principles the children will probably come to systematize. This is odd, since among the examples Katz reproduces are two finely executed clever cases. In one, a cube is drawn as two squares one atop the other. Presumably the top and front are shown, and presumably the sides are not shown because they are behind the top and front from the vantage point of the observer. This is a perspective drawing of sorts. Another shows a cube by a square with a rectangle on top. Presumably the rectangle shows the top surface of the cube foreshortened, because it slants away from the observer. This is indeed perspective drawing.

Katz, I conclude, found a great deal that is closely in keeping with later discoveries. But his interpretation was blinkered; he did not realize how good his charges were. It fell to later studies to repeat his findings and to realize their significance. On two points Katz was correct, though on one he hedged. Blind people can draw in outline (and quite well, on first attempt, with much more in common with the sighted than Katz surmised), and they have a good sense of three-dimensional shape and space.

TEACHING DRAWING AND CONSTRUCTING HUMAN FIGURES

George B. Wally pioneered the teaching of drawing to blind students in 1932. He has been tutoring students in reproducing particular shapes, varying the relative sizes of shapes to show depth, having lines converge to a vanishing point to show perspective, and applying color to suggest distant objects. His pupils master his system and learn to depict prototypical scenes-for example, landscapes. His great success is evident in the catalog of his collection (Wally, 1976), on the cover of which is a remarkable copy of Leonardo da Vinci's *Last Supper* by Maynard, a totally blind man 48 years old. The catalog includes exercises by Wally's blind pupils in two-point perspective, drawings of globes shown with latitude and longitude, drawings of candle flames, architecture, comets, the aurora borealis, bacteria, and portraits of Mao Tse-tung. Wally's results demonstrate that methods of technical drawing can be taught to the blind to good effect. Wally concludes, however, that the

blind students derived their understanding of space and perspective from his methods. It is more likely that students had considerable awareness of spatial layout before undertaking his classes and that his methods built on this foundation.

Susanna Millar (1991) of Oxford, one of the most influential investigators of tactile skills and pictures for the blind, examined the abilities of blind children (ages 5 to 15 years) to draw human figures and make flat models of human figures by arranging discs, ovals, and sticks. She compared the drawing task to the assembly task in order to test the role of skills in executing drawing motions. The assembly task requires much less skill than is required in drawing arcs, complete figures, and straight lines. Millar added a recognition task, since recognition is often thought to be easier than either drawing or assembling. It does not require placing the lines and arcs in carefully judged orientations or juxtapositions.

Millar divided the children into three groups of seven according to age (the middle group ranged from age 8 years 7 months to 11 years 3 months). She established a scoring system for the drawing and assembly tasks. Whereas oldest children as expected made more successful assemblies than drawings, the middle group scored equally well on the drawing task and the assembly task. The youngest group fared marginally poorer on assembly than on drawing.

Millar's observations on the children's procedures help to explain her results. She points out that drawing is not a task on which one succeeds or fails solely as a result of motor skills or executive plans that indicate where to start and where to finish. Instead, it involves a conception of what needs to be done. The youngest children Millar tested did not succeed in drawing the human figure particularly well because they set out with goals that have fairly little to do with drawing recognizable shapes. Rather, they would make a mark and assert that it stood for, say; an ear. Another mark they might announce as the tummy. A further squiggle might be said to be two legs. Revealingly; as Millar carefully points out, a mark might even be described as skin. The child seems make a list of features and represent them graphically by means of marks that have no significant shape.

Millar's observations of the production of drawings by the children in her study make sense of the results with assemblies. The assemblies are also used by the children to list properties of the referent. An arc can be a head, a circle can be a leg, and a square can be the other leg if shape is irrelevant. Millar reproduces one such display made by a seven-year-old boy totally blind since birth.

When the children were tested on two raised-line drawings of people and a drawing of a house made by Millar, the results were emphatic. No child recognized Millar's drawing as a house. Only one child recognized a stick figure drawing of a person, and only one child recognized a drawing of a person with lines standing for occluding bounds of an oval body and with stick-figure arms and legs. *If* the typical child brought the attitude to the display that shape was unimportant, lime wonder the displays were not spontaneously recognized.

Millar conjectures that at times it may be necessary to point out explicitly that shape is relevant. She asked a congenitally, totally blind eight-year-old to draw an arrangement of four toys set on the comers of a large square and joined by a rope. The blind child walked around the square, guided by the rope, and felt and identified each toy. Young blind children typically draw this arrangement in the same manner as young sighted children--as a long straight line with four marks on it, each indicating a toy. The blind eight-year-old, while drawing a long line, said, "The rope is a long shape. It's got some turns." Millar told her to draw the turns. This very minimal addition to the instructions on the task was sufficient to get the child to draw a four-sided figure with some creditable right angles. Millar's point is that the child's conception of the task, including decisions about the irrelevance of matters of shape, can result in assemblies or drawings or recognition performance that fails to reveal much of the child's understanding of shape.

Millar concludes that initially children, whether blind or sighted, probably do not use simple flat forms to represent three-dimensional objects on the flat page. Subsequently, she suggests, both the blind and the sighted do come to such uses of flat shapes. Millar's point helps to make intelligible the observation that a hint or a question about the referent, or the set of possible referents, can increase identification rates for displays considerably. Her case in point shows that the same argument holds for drawing. There is, however, an enormous gap between knowing that shape is relevant and knowing what to check in a figure one is trying to recognize, or what to put on paper to draw a particular figure. The more options open in the task, the more opportunity there may be to find out what the novice brings to its definition.

Millar contends that drawings are chiefly versions of hand movements which the blind child is using to map or symbolize body movements. The resemblances between "body movements, or movements exploring a solid object, and movements describing an outline on a page, are not always immediate or direct in blind conditions" (p. 320). The match to be made is between a body movement and a tracing on the page. Recognizing familiar shapes, Millar believes, depends on systematic movement. The movements should be "active" in the sense of being selected, organized, and physically made by the subject without intervention by the experimenter. This, Millar expects, Will

lead to better recall and recognition and more efficient familiarization with stimuli. Also, better memory and organization Will allow the person involved to spot" similarities between what are otherwise quite different forms of active movement (e.g. arm movement and locomotion)" (p. 321). Millar stresses that the efficient organization of movement often depends on obtaining clues from the context about what kind of object to expect, and the clues can bring out cognitive and inferential skills.

Much of what Millar proposes seems to be entirely appropriate. Information about relevance is often helpful. I suggest, however, that shape perception is in many ways independent of particular movements. The chief function of a movement is to gain information about shapes, and the layout of surfaces and lines can become known through a variety of movements. Just as sighted people can scan a visual scene with many different patterns of eye movements and yet always see a cube, so too we can feel the cube with one hand or two, one finger or many, with small or large arm movements, as we walk around the cube or turn it in our hands. The shape is invariant, but the movements are usually quite variable.

CONCLUSION

The drawing skills shown by blind adults attempting drawing for the first time are midway between the unrecognizable marks of the sighted child making drawings for the first time and the unmistakable accurate renderings of an adult draftsman aiming to be unambiguous and precise. Mostly the line elements are used by the blind in the universal outline style in which lines stand for edges and comers of various kinds. This use of the line seems accessible to blind adults even without tuition. Occasionally, however, there are other uses of line, such as for motion, that deserve some analysis. There are also matters of form and projection that call for attention. Sometimes forms are drawn from the side--"in profile," as Heller has it. Or the shapes of objects can be described as copied using a similarity geometry. At other times, rounded lips of glasses are drawn by straight lines. The blind person often realizes that the form drawn on the page as a rectangle, which appears to be a slab and not a cylinder, may nevertheless represent a glass, which is rectangular from the side. Likewise, a table can be drawn "from underneath." Hence projection of some kind, from certain directions, is often used. Tracy even went so far as to give a procedure, using a pencil, that models parallel projection. The mechanical procedure produces the same outcome as the drawing she made while thinking about projection without any mechanical aid.

The forms that the blind produce in drawing follow several principles for working with space and form and relating flat surfaces and lines to three-dimensional objects with continuous surfaces. The skills shown by the blind, and the spatial principles they understand, are likely to have a considerable history before our tasks tapped them in adult volunteers. But the evidence here indicates that this history is not a matter of rote learning. The blind volunteers have not been taught the possible meanings of lines or prototypical pictorial patterns for a set of referents, and they have not been taught how to use a particular principle to produce a picture in two dimensions of an object in three dimensions. The skills they show are products of understandings they possess as a result of abilities with line elements and general spatial principles that arise from the constitution of the perceptual systems and a general appreciation of the space around them available to several senses.

The levels of skills shown by blind adults are intermediate: they are several steps up from those of a beginner in early childhood, and yet they leave room for considerable improvement. Sophistication with principles, however, is not the same as accuracy with details. Blind adults often use what seem to be sophisticated principles although the drawing is not well executed, like a novice tennis player who has an understanding of good form but nonetheless keeps mis-hitting. I think that what previous researchers and, possibly, many educators of the blind have neglected is this distinction between understanding principles of varying degrees of sophistication, some developmentally early and some quite advanced, and executing them. The drawings by blind adults at times indicate a fair measure of skill in execution but, more important, they reveal principles, like projection from a vantage point, that are advanced even for many sighted adults. The principles and their level of sophistication in drawing development from child to adult, in the sighted as well as the blind, need careful assessment. I surmise that when that assessment is completed it will be evident that blind adults who have not been taught how to draw or use pictures are several steps above sighted children beginning to draw, that blind children are on a par with sighted children at the outset, and that much of what underlies drawing development can be understood to be a broad advance in mastery of space common to the blind and the sighted, and accessed by touch as well as by vision.