Participation in the arts is central to human behavior. The earliest humans made art and traces of artistic ability can be seen in nonhuman animals. The arts are critical to the development of cognitive, social, and affective capacities in children and are included in the Handbook for the first time in the present edition.

I review the developmental course of the comprehension and production of two major nonverbal art forms, drawing and music, focusing on typical development in the absence of formal training. Research on individual differences and on giftedness in the arts is not covered (but see Moran & Gardner, Chapter 21, this Handbook, this volume for a discussion of giftedness). Unfortunately, almost all of the research on drawing and music has been conducted in Western settings, with a few exceptions (reviewed here).

Research on drawing has focused on production whereas research on music has focused on perception. This asymmetry, reflected here, may be due to the fact that the earliest music children produce is song rather than notated compositions. Songs are fleeting, while drawings are permanent and thus perhaps more amenable to study.

For each art form, I consider the following questions:

- What does an investigation into the evolutionary roots of this art form tell us?
- What historical, theoretical, and methodological approaches have been taken in the study of this art form?
- What are the major milestones in the development of comprehension and production of this art form?

For both drawing and music, I also consider one of the most enduring and provocative questions in the developmental study of the arts—whether development improves linearly with age, or whether some artistic abilities decline with age or are U-shaped, with young children responding more like adult artists than older children. This question is far more acute with respect to the arts than for logical, mathematical, scientific, or moral reasoning, where linear development is the normal expectation.

**DRAWING**

Drawing is a complex activity that involves motoric, perceptual, and conceptual skills, including the use of schemas and rules specific to pictures (Gombrich, 1977; Thomas, 1995). Adults with no special training in drawing are able to translate a three-dimensional scene into a recognizable two-dimensional representation. While their drawings may not look highly skilled or accurate,
their accomplishment is impressive: They can represent objects in a recognizable manner even though there is little actual similarity between a real-world scene and its small two-dimensional representation.

Pictures pervade our lives—we see them not only in art museums but also in magazines, billboards, cereal boxes, and so on. Pictures can be nonrepresentational (as in designs, abstractions) or representational, and, if the latter, they can be either realistic or nonrealistic. Nonrealistic representations are as easily recognized as realistic ones (witness cartoons, caricatures, and children’s drawings). When we read a picture as a work of art (e.g., rather than as a diagram or scientific illustration), we attend to aesthetic properties—specifically we attend to what the picture expresses (properties not literally present such as sadness, agitation, loudness), the style of the work (the artist’s individual handprint), and its composition (the organization of its parts and its balance or lack thereof; Arneheim, 1974; Goodman, 1976).

We can speculate about the evolutionary base of the visual arts from what we know about early human art as well as nonhuman capacities in picture-making and picture-responding.

**Evolutionary Base**

The drawings of the earliest humans, from over 30,000 years ago, are extraordinarily realistic, capturing the fluid contours of the animals they hunted. Cave paintings have been likened in skill to the most highly prized human drawings (e.g., to drawings by Picasso). Cave art testifies to the drive to create art in humans: The earliest humans crawled through tunnels into deep recesses in caves to paint. The function of cave art has been debated (was it to encourage hunters? was it religious?) and we will only be able to speculate on this question. Perhaps the function was purely aesthetic, perhaps it was ritualistic, most likely it was polyfunctional. We also will never know what proportion of the population was able to draw in this way.

The visual arts extend to the nonhuman realm but only in a very limited manner. Apes and monkeys can recognize two-dimensional depictions of objects (Davenport & Rogers, 1971; Zimmerman & Hochberg, 1970; but see Winner & Ettlinger, 1979). Chimps have shown a sense of visual balance: Given a page with a small figure off-center, chimps added marks in a location that balanced the marks (Schiller, 1951). Morris (1967) gave painting materials to Congo, a laboratory chimp, and noted certain resemblances between Congo’s spontaneous paintings and those by very young children. Paintings by chimps in the laboratory have been confused with abstract expressionist paintings, though surely the intentions behind the chimp and adult works were not comparable (Hussain, 1965). Chimps trained in sign language have shown the ability to make a rudimentary drawing and then, using sign language, label the object drawn, revealing an understanding that a mark on a page can stand for something in the three-dimensional world (R. Gardner & Gardner, 1978; Patterson, 1978). And when Premack (1975) gave three chimps a photograph of a chimpanzee head with the face blanked out and offered them the cut out eyes, nose, and mouth, one of the three chimps was able to place these parts in correct position. But the fact remains that no nonhuman animals draw spontaneously, and even when given drawing and painting materials, chimps make only nonrepresentational marks (with the possible exception of those trained in sign language). The achievements of humans in the realm of visual arts are far more impressive, even in infancy.

**Historical and Theoretical Approaches**

Psychologists have long been fascinated by the oddities of children’s drawings when compared to those of even untrained adults. Why do children act out their scribbles as they draw and then give the resulting lines a name that looks nothing like what is drawn? Why do children all over the world today draw humans as “tadpole” figures (a circle with arms and legs radiating out of it, and two eyes) when they know that people don’t look like this? Why were two-eyed profiles, such as that in Figure 20.1a drawn by nineteenth-century but not twentieth-century children? Why do they show one object behind another as if the object in front were transparent, as in the “transparent” boat in Figure 20.1b? Why do they draw objects in the same scene from mixed viewpoints, showing, for example, trees “folded out” from both sides of a street, as in Figure 20.1c?

The study of children’s drawings began at the end of the nineteenth century with the rise of the field of child development. Early investigators include Barnes (1894), Hall (1892), Kerschensteiner (1905), Lukens (1896), Luquet (1913, 1927), Maitland (1895), Ricci (1887), Rouma (1913), and Sully (1895); for reviews, see H. Gardner (1980), Golomb (2002, chap. 2), and Strommen (1988). Drawings (like language) were seen as a reflection of de-
Developmental stages, and parents, psychologists, and educators began to collect children’s markings and to create descriptive taxonomies of drawing stages. The many oddities of children’s drawings were seen as deficiencies reflective of children’s immaturity and indicative of their incomplete or oversimplified concepts of the objects they were drawing.

The French art historian Luquet (1913, 1927) proposed three phases in the development of realism—a claim that remains influential yet controversial. At ages 3 to 4, Luquet theorized, children are in the phase of synthetic incapacity, or failed realism, in which they are unable to capture the spatial relationships among objects. From 5 to 8, children are in the phase of intellectual realism in which objects are depicted in canonical (stereotypical) position rather than from the particular viewpoint of the child drawing. At this phase, he argued, children draw what they know rather than what they see. Drawings are based on children’s internal models (i.e., a table top is drawn as a rectangle because the child knows it to be rectangular; a near object appears transparent because the child shows what she knows to be behind it; a cup is always shown with handle even if the handle is not visible because the child knows cups have handles).

After age 9, according to Luquet, children enter the phase of visual realism. Now they draw what they see, basing their drawings on how things look from a single viewpoint, even if this means distorting an object by making it partially occluded or by altering its shape (e.g., drawing a table-top as a parallelogram despite knowing it is in reality a rectangle).

Piaget and Inhelder’s (1956) studies of children’s drawings were influenced by Luquet (1913, 1927), and exemplify this “deficiency/progressing toward realism” tradition. They saw the development of drawing as guided by the child’s developing understanding of space. Following Luquet, they described a progression characterized at age 3 to 4 by synthetic incapacity in which children draw bounded objects (e.g., a closed circle) but ignore size and shape. Children at this age draw the human figure as a tadpole, and this figure was understood by Piaget and Inhelder to reflect not deficient perception but deficiencies in spatial representation. From age 4 to about 7 or 8, children were said to enter the stage of intellectual realism where they draw what they know not what they see. At the concrete operational stage, children were said to be able to draw in a realistic way, reflecting their understanding of Euclidean geometry and their emergence from spatial egocentrism. Piaget and Inhelder argued that at this stage the child could represent the third dimension (through occlusion and perspective). Thus, they saw drawing stages as progressive and assumed the desired endpoint to be visual realism. However, few concrete operational age children are able to draw in correct perspective (Willats, 1977), making it difficult to assume a close tie between concrete operational reasoning and realism in drawing (see Golomb, 2004, chap. 4, for further discussion of this issue).

The assumption that children’s drawings become increasingly realistic with development led to the use of children’s drawings as measures of intelligence, with
higher scores for more detail and more accurate alignment of parts and proportion (Goodenough, 1926; Harris, 1963). Piaget and Inhelder’s (1956) description of the shift from intellectual to visual realism, and their assumption that the oddities in children’s drawings reflect what children know about an object rather than what they see, pervaded theories of children’s drawings for many years. But as will be shown later, the assumption that the errors children make in their drawings are direct windows into their level of conceptual understanding is wrong. Even adults know far more about an object that they can show in a drawing: We can recognize our errors but simply have not acquired the rules for drawing complex objects or scenes (Golomb, 1973; Morra, 1995; Thomas, 1995). Such a view also reveals a Western-centric assumption of realism as the end state in the history of art. This assumption is misguided because the earliest human art (the art in the caves) is exceptionally realistic and because many cultures did not develop realistic art.

Although the study of children’s drawings began with the emergence of the study of child development, this topic was gradually relegated to a minor area of developmental psychology. Just compare the number of developmental psychologists who study memory, language, and number versus those who study drawing. By the 1970s, children’s drawings went unmentioned in many developmental textbooks (Thomas & Silk, 1990).

Freeman’s (1980) experimental approach to children’s drawings helped to revive the study of child art and to bring this study into the arena of cognitive developmental research. Freeman argued that children’s drawings reflect production problems rather than conceptual limitations. For example, he argued that tadpole figures, which appear to have no body, stem from the strategy of drawing in linear fashion from head to legs. This causes children to fall prey to the serial order effect, remembering the first and last items of a list (head, legs) but forgetting the middle (trunk). Hence, his “production deficit” hypothesis of children’s drawings diverges from Piaget and Inhelder’s (1956) view that drawings reflect deficiencies of spatial representation.

Willats’s (1995) information-processing theory of picture production (based on Marr’s, 1982, theories of the visual system) also brought the study of child art into the arena of experimental cognitive development. Both Willats and Freeman (1980) distinguished between object-centered descriptions (in which shapes are not distorted) and viewer-centered descriptions (in which shapes are distorted to show how they look rather than how they actually are). What develops, for Willats, is a set of different drawing systems, from topological relations to various kinds of projection systems, with the final one being linear perspective. He also argued that denotation systems develop with two-dimensional regions first standing for volumes and later for surfaces of objects, and with one-dimensional lines ultimately standing for edges and contours. Willats’s and Freeman’s view that drawings develop from object-centered to viewer-centered descriptions parallels Piaget’s view of the movement from intellectual to visual realism. Willats stands out however in his focus on the acquisition of drawing-specific rules for the emergence of visual realism.

In striking contrast to the deficit models of children’s drawings was a more positive view put forth by artists and art educators at the beginning of the twentieth century. These artists and educators championed the striking resemblance between child art and emerging styles of Western art—impressionism, cubism, abstract expressionism—and organized exhibitions of child art (Fineberg, 1997; Golomb, 2002; Viola, 1936). Artists such as Kandinsky, Klee, and Picasso used child art as sources of inspiration for their own art (H. Gardner, 1980; Golomb, 2002). Arnheim (1974), the leading spokesperson for the aesthetic view, argued that children’s art had its own aesthetics and was not just a sign of children’s underdevelopment. He pointed out that many of the distortions and oddities found in children’s drawings (e.g., fold-out drawings, lack of depth, transparencies) can be found in non-Western art (Paleolithic, Egyptian, South Sea Island, Kwakiutl Indian art, or pre-Renaissance Western art), showing us how many ways there are to represent and how much tolerance we have for lack of realism (cf. Deregowski, 1984, pp. 120–122). Arnheim (1974) argued that children’s drawings are not failed attempts at realism but instead are intelligent solutions to the problem of depicting a three-dimensional world on paper. Arnheim interpreted children’s drawings as graphic “equivalents” that are clear and readable and no more “deficient” than nonrealistic art produced by adult artist throughout the centuries.

A serious limitation of much of the experimental research on children’s drawing to be reviewed later is the focus on how children represent geometric forms (e.g., copying cubes). Moreover, experimental studies have often used artificial tasks instead of analyzing properties of children’s spontaneous drawings. Hence, many
studies yield drawings very different from ones that children produce on their own. For instance, asking children to draw a cup positioned so that the handle is not visible may test whether they incorrectly make the occluded handle visible, but children probably would not choose to draw a cup from observation in their spontaneous drawing. These experimental approaches typically ignore the “aesthetics” of children’s drawings and their ecological validity has been challenged (Costall, 1995). As is discussed later, studies of the development of music comprehension have also been criticized for using artificial stimuli rather than real pieces of music. However, studies using artificial tasks are useful because they test hypotheses about the limits of the child’s capacities.

We turn now to a consideration of how children develop the ability to make sense of pictures, followed by a consideration of how they develop the ability to produce pictures.

Picture Recognition, Comprehension, and Preference: Major Milestones in Development

Understanding pictures requires that one recognize pictures as representations. Understanding pictures also requires the ability to perceive the illusion of the third dimension in a two-dimensional picture, as well as the ability to perceive aesthetic properties of pictures. The development of these abilities is reviewed here, followed by a consideration of children’s aesthetic sense—as measured by the kinds of pictures preferred at different ages.

Understanding the Representational Nature of Pictures: Four Components

The representational information carried by pictures is far more impoverished than information available in the ordinary environment: Objects are smaller than in real life, color is frequently lacking, and edges of objects are often represented by lines despite the fact that objects in the real world do not come with outlines. In addition, pictorial information is contradictory: Certain depth cues suggest the third dimension, while other information (e.g., from binocular and motion parallax) shows the surface of the picture to be flat.

Understanding the representational nature of pictures is four-part: A person must recognize (1) the similarity between a picture and what it represents, (2) the difference between a picture and what it represents, (3) the dual reality of a picture as both a flat object and a representation of the three-dimensional world, and (4) the fact that pictures are made with intentionality and are to be interpreted. Infants are excellent at the first two understandings while the third and fourth kinds develop later.

Recognizing the Similarity between a Picture and What It Represents. Infants need no special instruction in reading pictures, even when these are small black-and-white line drawings (Hochberg & Brooks, 1962), which is a finding consistent with Gibson’s (1979) view that pictures convey the critical information available from the world. Hochberg and Brooks kept their child from seeing any representational images until the age of 2, and then presented him with pictures of familiar objects such as a shoe or key (drawings, then black-and-white photos). The child labeled the pictures correctly, showing that no one needed to teach him to recognize objects represented in pictures. Later research with infants has confirmed this finding (Daehler, Perlmutter, & Myers, 1976; DeLoache, Strauss, & Maynard, 1979; Dirks & Gibson, 1977; Fagan, 1970; Fantz, Fagan, & Miranda, 1975; Field, 1976; Rose, 1977; Ruff, Kohler, & Haupt, 1976). Twelve-month-olds can even recognize line drawings of common objects when much of their contour has been deleted (Rose, Jankowski, & Senior, 1997). Thus, understanding what a picture represents is an untutored skill, in contrast to understanding what a word stands for—an understanding that must be learned because words have an arbitrary rather than iconic relationship to their referents.

The fact that adults in cultures without pictures can, with some effort, read what pictures represent helps to confirm the conclusion from infant research that all one needs to recognize what a picture represents is experience with the actual objects represented (Deregowski, 1989; Deregowski, Muldrow, & Muldrow, 1972; Jahoda, Deregowski, Ampene, & Williams, 1977; Kennedy & Ross, 1975). The exception are those pictorial schemas that are highly conventional (such as the depiction of a flying bird by a W-type shape), and thus, like words, require learning (Nye, Thomas, & Robinson, 1995).

Recognizing the Difference between a Picture and What It Represents. Are young children realists when it comes to pictures? Piaget argued that children confuse the sign with the thing signified, referring to
this trait as ‘realism’ (Piaget, 1929). If children are realists, they should succeed at recognizing what a picture represents but fail to distinguish a picture from its referent. In one sense, children are not realists about pictures. Infants discriminate between photographs and their referents between 3 to 6 months of age (Beilin, 1991; DeLoache, Pierroutsakos, & Uttal, 2003; DeLoache, Strauss, & Maynard, 1979); and 3- to 4-year-olds can readily sort pictures from objects (Thomas, Nye, & Robinson, 1994). For a review of such early pictorial competence, see DeLoache, Pierroutsakos, and Troseth (1996).

But in another sense, children are realists about pictures. Despite their ability to discriminate pictures from objects, they sometimes see pictures as ‘substandard’ versions of real objects possessing some of the properties that only the real objects possess (Thomas, Nye, & Robinson, 1994). Ninio and Bruner (1978) described one child who, between 8 to 18 months of age, tried to manipulate pictured objects. Pierroutsakos and DeLoache (2003) described 9-month-olds manually exploring pictures of objects as if they were the real thing. This behavior occurred despite infants’ ability to select the actual object when given a choice between the pictured versus real object (DeLoache, Pierroutsakos, & Uttal, 2003). By 19 months, the infants had stopped grasping at pictures and now pointed to them.

But even preschoolers can become confused. Beilin and Pearlman (1991) gave 3- and 5-year-olds pictures of objects such as a rattle along with life-size photos of the same objects and asked them about the physical and functional properties. Three-year-olds had some difficulty with these questions, especially those about physical properties, sometimes believing, for example, that a picture of a rattle makes a noise when shaken. They had less difficulty with functional properties, usually realizing that one cannot eat a picture of an ice cream cone, for example. Five-year-olds had no trouble with either type of question, and among the 3-year-olds, errors were made only by some. From this study it would appear that by the age of 3, most children are no longer pictorial realists.

Still, young children are not completely clear about the relationship between a picture and what it represents. They believe that a picture shares the fate of its referent, showing that they have not completely separated picture from referent. Beilin and Pearlman (1991) asked the same 3- and 5-year-olds what would happen to a picture of a flower if the real flower it depicted were altered and found that children think that the picture would change too (though this kind of response was more prominent among the 3- than the 5-year-olds). Zaitchik (1990) reported similar results when she showed 3- and 4-year-olds a toy duck on a bed and took a Polaroid photograph of the duck. Children then saw the toy duck go into a bath and were asked to predict what the photograph would show. Forty percent said that the photograph would show the duck in the bath. The finding that an already completed picture changes to match a subsequent change in its referent was replicated by Charman and Baron-Cohen (1992), Leekam and Perner (1991), Leslie and Thaiss (1992), and Robinson, Nye, and Thomas (199), though it is not clear whether children believe that the picture actually changes as the referent changes or whether they simply confuse the properties of picture and referent due to forgetting. Thus, there remains support in the domain of picture perception for Piaget’s claim that young children are realists.

Recognizing the Representational Status of Pictures. Children under 2.5 years of age do not grasp that a picture stands for its referent. Callaghan (1999) showed 2-, 3-, and 4-year-olds several balls differing in size and features. The experimenter held up a picture to show which ball should be dropped down a tunnel. Two-year-olds could not use the pictures as symbolic objects and thus selected balls randomly rather than selecting the one that matched the picture. Sometimes they even put the picture down the tunnel instead of the object, showing that they treated the pictures as objects.

By 2.5 years, children can understand the representational status of pictures. DeLoache (1987) showed children color photos of a room, each indicating where a toy was hidden in the actual room. The experimenter pointed to one of the photos to show the child where to search for a toy hidden in the room. Children aged 2.5 years could use the photos to find the toys, showing that they recognized the photos as representational objects. However, they could not find the hidden toy in the actual room when their cue was a scale model of the room with a hidden toy in the model. The contrast in findings led to the conclusion that children cannot treat a scale model as both an object and a symbol because they can’t stop thinking of the model as an object. In contrast, they can treat a picture as a symbol because a picture is primarily only a representation and not an object.

However, Callaghan (2000a) has found that children do not fully understand the symbolic nature of pictures until age 3. Under age 3, children rely on verbal labels...
to mediate the matching of picture with referent. Further evidence for incomplete understanding comes from DeLoache (1991) who showed that 2.5-year-olds can be fooled into treating pictures as objects and hence fail to see them as symbols. When a miniature dog was hidden behind a photo of a chair (to indicate where the dog could be found in the room), children failed to retrieve the dog from behind the chair. In this condition, they treated the photograph as an object and could not use it as a clue to the location of the toy (see also Dow & Pick, 1992).

Children can actually succeed on DeLoache’s (1991) task simply by attending to what the picture represents. Attending to the dual identity of a picture (i.e., recognizing that a picture of a flower is both a flower and a flat piece of paper) is not tested by her task and remains more difficult for children. Thomas, Nye, and Robinson (1994) showed children an actual flower, a color photo of a flower, and a plastic replica of a flower and asked them to label and handle each one. The alternative identity of the plastic and pictured flower was then explained (e.g., it does not really grow in the ground), and children were then asked an appearance question (Does it look like a flower?) and a reality question (Is it really a flower?). Four-year-olds made some errors when asked about the plastic and pictured flower, and most errors were realistic ones in which they confused the representation with the referent (saying it both looked like a flower and was a flower).

Thus, while infants recognize pictures, it is not until at least 4 years of age that children fully understand the symbolic nature of pictures and grasp the dual identity of a picture. Some children under age 4 believe that a picture has some of the visual properties of its referent and that a picture changes as its referent changes; some also confuse the picture with its referent when asked to consider both of the picture’s identities. These errors could be due to a difficulty holding in mind two interpretations of the same input (Flavell, 1988) or to being confused by the experimenter’s questions. Errors might also be the result of how adults talk to children about pictures: We assume an understanding of (and gloss over) the dual identity of pictures, referring to a picture of a horse, for example, as simply “a horse” (Nye, Thomas, & Robinson, 1995). The way out of this confusion may be simply through learning—through experience with pictures.

Acquisition of an Intentional Theory of Pictures. Full understanding of pictures requires the realization that pictures are made by someone with a mind. The “artist” interprets what is seen and puts it on paper. Thus, beauty is not directly transferred from world to paper but is a matter of the artist’s interpretation of what he or she sees. Moreover, the beholder too has a mind, and this affects how the picture is perceived (Freeman, 1995; Gardner, Winner, & Kircher, 1975).

Snippets of understanding the intentional basis of pictures can be seen in 3-year-olds. Bloom and Markson (1998) asked 3- and 4-year-olds to draw a lollipop and a balloon and both drawings looked the same. Later children were asked to label each, and they used their prior intentions to label each picture. Similarly, 3-year-olds were more likely to label a drawing as a picture of something if told that the picture was drawn intentionally rather than as a result of spilled paint.

Richert and Lillard (2002) found that children under age 8 are easily confused about the role of the artist’s intention in determining what a picture represents. Even if they are told that an artist had no knowledge of a certain object, if the drawing produced looks like that object, children say that this is what the artist was drawing. Parallel findings were reported by Richert and Lillard in another representational domain—that of pretense: Children under age 8 did not realize that a person cannot pretend to be a rabbit if they have never heard of a rabbit.

Studies have not pinpointed what causes the emergence of understanding of the role of intention in drawing. However, one likely catalyst is the experience of having one’s own drawings misinterpreted, which could lead children to reflect about how their intentions determine the meaning of their drawings. Another possible mechanism of change is children’s developing general ability to introspect (Flavell, Green, Flavell, & Grossman, 1997).

Freeman and Sanger (1993) found that subtle misunderstandings about the role of the artist in picture making persist until adolescence. When children were asked whether an ugly thing would make a worse picture than a pretty thing, most 11-year-olds said yes (revealing a belief that beauty flows directly from the world to the picture), but most 14-year-olds said no (they said that whether the picture is pretty or not depends on the artist’s skill). Thus, the older children recognized that the artist determines whether a picture is beautiful. These findings about pictures are but one of many manifestations of a developmental progression in epistemological understanding by which children gradually come to understand that knowledge has its origin not only in
the external world but also in the mind (see Kuhn & Franklin, Chapter 22, this Handbook, this volume).

Perceiving Depth in Pictures

To perceive depth in a picture, one must overlook three kinds of cues that indicate that the picture is flat. First, binocular disparity is a cue resulting from small differences in how a scene looks to each eye. The farther away an object, the less disparity between the two views. In a picture, objects meant to appear far away are the same distance from our eyes as objects meant to appear near, which is why binocular disparity tells us that the two objects are on the same plane. Second, binocular convergence is a cue given by the fact that our eyes converge on what we focus on. For near objects, the angle of convergence is greater than for distant objects. This angle of convergence is interpreted by the brain as information about distance. But when we look at a picture, the angle of convergence is identical for images meant to be near and far in the picture because all of the objects are on the same flat picture plane. Third, motion parallax is a cue yielded by moving our head as we view a scene. When we do so, nearer objects are displaced faster than farther ones. But when we move our head in front of a picture, near and far represented objects move at the same rate, declaring the surface to be flat.

These three cues tell us that a three-dimensional scene is three-dimensional, and that a picture is only two-dimensional. How then do we perceive depth in two-dimensional pictures? We do so by ignoring these cues in favor of pictorial depth cues. These include occlusion (near objects partially occlude far ones), linear perspective (receding lines converge toward a vanishing point), size diminution (distant objects are smaller than near ones of the same absolute size), relative height (distant objects are drawn farther up on the picture plane), and texture gradients (textures get denser in the distance).

Infants perceive depth in the three-dimensional world when the nonpictorial cues of motion parallax and binocular cues are available, but they fail to read depth in pictures (Bower, 1965, 1966; Campos, Langer, & Krowitz, 1970). Children between the ages of 2 and 3, however, can judge which of two houses in a picture is farther away using either occlusion cues or the cue of relative height (Olson & Boswell, 1976). The addition of the linear perspective cue of converging lines did not result in improvement in children’s pictorial depth perception for 3- to 5-year-olds, who still relied on occlusion and relative height (Olson, 1975). Some studies have shown that children as old as age 5 can use relative height as a depth cue only in combination with other depth cues, such as partial occlusion (M. Hagen, 1976), or in a context showing the position of the objects with respect to the vanishing point in the picture (Perera & Cox, 2000). For other studies on pictorial depth perception in children, see Olson, Pearl, Mayfield, and Millar (1976); Wohlwill (1965); and Yonas, Goldsmith, and Hallstrom (1978).

While children as young as age 3 can use certain cues to judge whether one object is farther than another in a picture (relative depth judgment), the ability to determine precisely how far away a pictured object is meant to be relative to others develops later. Children as old as age 7 are less accurate than adults on such tasks (Yonas & Hagen, 1973). Even adults fail to make precisely accurate metric judgments about pictures: We read pictures as flatter than they should be read given the pictorial cues (Hagen, 1978). Perhaps the binocular and motion parallax cues that show the picture to be two-dimensional dilute the pictorial cues that yield the three-dimensional illusion.

Cross-cultural evidence suggests that the ability to read depth in pictures is not a skill that requires prior exposure to pictures. Children and adults in cultures with little or no exposure to pictures representing depth can read pictures as representations of three-dimensional scenes (Hagen & Jones, 1978; McGurk & Jahoda, 1975), despite Hudson’s (1960) earlier claims that they could not. Like the ability to recognize what is represented in a picture, the ability to perceive depth in a picture may develop simply as a function of experience perceiving the actual world.

Perceiving Aesthetic Properties of Pictures: Expression, Style, and Composition

Most research on the perception of pictures has focused on the perception of representation (the same is true of research on drawing, as is shown later, where researchers focus on the development of the ability to represent). However, a few studies have examined sensitivity to nonrepresentational, aesthetic aspects of pictures—in particular to expression, style, and composition. Detection of these features calls on skills quite different from those required to perceive representational properties of pictures.

Expression. Pictures can express properties they do not literally possess. They can express nonsensical properties (loudness) and moods, doing so via represen-
tational content (a dying tree expresses sadness) or formal properties (dark colors express sadness; note that the depiction of a sad face is a literal rather than an expressive way to depict sadness). Because expressive properties are not literally present in pictures, reading expression in pictures can be considered a form of metaphorical thinking, and expression in art has been referred to as “metaphorical exemplification” (Goodman, 1976).

On very basic tasks, identification of expression in visual forms has been shown to emerge very early and may rely on universal, innate sensitivities. Even babies (age 11 months) have some capacity to perceive cross-modal (visual-auditory) similarities that might underlie metaphors: They can match a dotted line to an intermittent tone (both broken), and a continuous line to a continuous tone (both smooth; Wagner, Winner, Cicchetti, & Gardner, 1981). Preschoolers are sensitive to the expressive properties of abstract (nonrepresentational) stimuli, such as angular lines versus softly curving lines and bright colors versus dark colors (H. Gardner, 1974; Lawler & Lawler, 1965; Winston, Kenyon, Stewardson, & Lepine, 1995), and to expressive properties of certain kinds of representational content (e.g., a dying tree as sad; Winston et al., 1995). Shown abstract paintings, 5-year-olds respond with the same mood labels as do adults (Blank, Massey, Gardner, & Winner, 1984; Callaghan, 1997; Jolley & Thomas, 1994) though studies conflict in their reports of which emotions are best recognized in pictures by young children. When directly questioned about the mood in a drawing, children (including non-Western ones) as young as age 4 are typically correct (Jolley & Thomas, 1995; Jolley, Zhi, & Thomas, 1998a). While children may incorrectly match a “happy” painting (as judged by adults) with an excited face, they do not match it with a sad face, thereby showing a sensitivity to the positive or negative valence expressed by the picture even if they miss the precise mood (Callaghan, 1997). Children make the same kinds of errors when perceiving emotions in faces (Russell & Bullock, 1985). And even 3-year-olds can reliably select paintings that express happy, sad, excited, and calm, but only after first seeing adults modeling these judgments in other paintings (Callaghan, 2000b).

On more challenging expression tasks, young children do not succeed. When simply asked to select an appropriate completion for a picture, one of which matched the mood in the picture (e.g., a wilted tree versus a blooming tree to complete a sad picture), children did not succeed until 10 to 11 years of age (Carothers & Gardner, 1979; Jolley & Thomas, 1995). Here, no mention was made of mood. When Winner, Rosenblatt, Windmuller, Davidson, and Gardner (1986) asked 7-, 9-, and 12-year-olds to pair abstract and representational paintings on the basis of their expressive property, only the two older age groups performed above chance. This latter task was a challenge because the abstract painting was not labeled for the child as sad, happy, excited, or calm; instead, children had to discern the mood expressed in the abstract picture and then match it to the mood conveyed by the representational picture.

**Style.** Features that distinguish one artist’s style from another are hard to define and include a wide variety of properties such as level of abstraction, texture, brush stroke, color, and light. Children’s ability to detect style in works of art has been studied through paradigms in which children are asked to match works by the same artist. Whenever it is possible to match on the basis of representational content, representation trumps style (H. Gardner, 1970). Jolley, Zhi, and Thomas (1998b) showed Chinese and English children triads of pictures and asked them to match two of them. Matches could be made on the basis of color, subject matter, or what was referred to as visual metaphor (e.g., two different objects both broken). Both Chinese and English children matched on color at age 4 and on subject matter by age 7. Though metaphorical matches increased between 7 and 10, subject matter remained predominant at age 10.

In matching tasks in which the choices vary in style but not subject matter, preschoolers and even 3-year-olds can perceive which paintings are by the same artist, though they justify such matches only in global terms such as looking alike (H. Gardner, 1970; Hardiman & Zernich, 1985; O’Hare & Westwood, 1984; Steinberg & DeLoache, 1986; Walk, Karusitis, Lebowitz, & Falbo, 1971). When asked to pick out their own drawing from drawings by a range of children (all of the same subject matter and 3 months after having made the drawing), even 3- to 4-year-olds succeeded, showing that they recognized their own style. Five- and 6-year-olds even recognized their own drawings after a 1-year delay (Gross & Hayne, 1999).

In a more difficult style perception task, children were asked to complete a drawing by adding a person the way the artist would have done it (Carothers & Gardner, 1979). They were given a choice of two drawings of people, one of which used the same line quality as the target drawing. Six-year-olds chose at random, but 9-year-olds selected the completion in the appropriate style of line.
Thus, when only line quality was varied, 6-year-olds failed to match by style. This was a difficult task, however, because children were not directly asked to match by line quality.

Composition. Infants pay attention to the external contour of a pattern but not to the internal organization of its parts (Bond, 1972); sensitivity to the internal structure of a pattern develops gradually between the ages of 4 and 8 (Chipman & Mendelson, 1975). This was demonstrated by asking children to judge which of two patterns identical in external contour was simpler. The ability to look through the content of a painting to perceive its structure develops only by late childhood and early adolescence: When asked to sort groups of four paintings two of which had similar composition and two of which had similar content, classification by subject matter decreased with the main increase between ages 7 to 11 (H. Gardner & J. Gardner, 1973).

Taken together, studies of children’s perception of aesthetic properties of pictures show that by age 3 or 4, children have the ability to perceive aspects of expression, style, and composition. However, when representational content is pitted against one of these non-representational properties and competes for the child’s attention, representation wins out and children ignore the aesthetic property.

Aesthetic Responses
Aesthetic responses to pictures depend on what is perceived in pictures. Little research has examined aesthetic reactions to pictures, and the research that has been carried out has been limited to the study of the kinds of pictures children prefer.

The Appeal of Realism. Parsons (1987) documented developmental changes in the bases of children’s aesthetic preferences by interviewing children about their responses to different works of art. The 4- to 7-year-olds he interviewed liked abstract works as much as realistic ones. Between ages 7 to 10, children judged paintings as good only if they were realistic in form and color. In early adolescence (ages 10 to 14), expressive properties become more important than realism. By later adolescence, individuals begin to judge works by their social and historical context.

Parsons’ (1987) study was carried out on only eight paintings and contained no statistical demonstration of a stage theory of aesthetic judgment. A more quantitative study by Linn and Thomas (2002) failed to find evidence for a stagelike progression in aesthetic preferences: From age 4 to adulthood, individuals used subject matter more often than any other property of a painting in explaining why they like it. Only for art students (who focused on the medium) was subject matter not the dominant criterion invoked, but even for them content was the second most often cited reason for liking a work. Even 2- and 3-year-olds show a preference for realism (McGhee & Dziuban, 1993). For other studies showing the appeal of realism for children, see Machotka (1966) and Rosenstiel, Morison, Silverman, and Gardner (1978).

Children prefer more realistic drawings of the human figure than they themselves can produce, and this finding holds for children at the scribbling stage on up to adolescence (Jolley, Knox, & Foster, 2000). Children also prefer perspective drawings that are more advanced than they themselves can produce (Kosslyn, Heldmeyer, & Locklear, 1977; H. Lewis, 1963). Thus, production lags behind preference (but see Brooks, Glenn, & Crozier, 1988, who found that preschoolers preferred drawings at their own level to drawings that were more complex).

The Appeal of Regularity. Two studies have examined preference for regularity and have shown that children respond positively to balance. Infants (12-month-olds) show a preference for vertical symmetry (symmetry across a vertical axis) over both asymmetry and horizontal symmetry (Bornstein, Ferdinandsen, & Gross, 1981). The preference for vertical symmetry could be due to experience in a visual environment dominated by such symmetry, especially the vertical symmetry of the face and body. And children ages 4, 6, and 10 prefer balanced drawings to unbalanced ones (Winner, Mendelsohn, & Garfunkel, 1981).

Eysenck and his colleagues also reported studies claiming to show a preference for regularity in childhood as well as adulthood, but what he studied was the ability to distinguish regular from irregular forms (Japan, Hong Kong, Singapore; Eysenck, Götz, Long, Nias, & Ross, 1984; Götz, Borisy, Lynn, & Eysenck, 1979; Iwawaki, Eysenck, & Götz, 1979). Eysenck devised a test consisting of pairs of nonrepresentational forms identical except for the fact that one member had
been changed so that eight artists considered the original to be superior in harmony, design, and “good gestalt.” People taking this test were told that one member of each pair had been deemed more harmonious by art experts. They were told to pick out the less harmonious design and were explicitly told that this was not the same as being asked to pick out the one they found more pleasant. Children from 10 to 17 were tested along with art students over 17 years of age, and no relation was found between “visual aesthetic sensitivity” and age or education. No effect of culture was found when children and adults from Japan, Hong Kong, and Singapore were compared to Westerners.

The work of Eysenck demonstrates that children at least after age 11 are near adultlike in their judgments of what counts as harmonious. However, had the instructions asked for preference, the results might have differed. Perhaps older children or those trained in art would show a greater preference for the irregular forms because they are more surprising.

**Telling a Good Painting from a Less Good One.** Children often prefer works other than those considered “great” by experts in art. Child (1965) showed 6- to 18-year-olds pairs of pictures similar in style and content but in each case one member of the pair had been judged aesthetically superior by art experts. Participants were asked which one they preferred. Between the ages of 6 and 11, children agreed with the experts only about a third of the time. Between 12 to 18 years, agreement with experts rose, but peaked only at 50% by the oldest age. That agreement never rose above 50% shows that young adults (age 18) do not hold the same aesthetic preferences as do experts in the arts, conflicting with Eysenck et al.’s (1984) claims for universality. These findings suggest either that training in the arts shifts the bases of aesthetic preferences, or that those who go into the arts have different preferences to begin with.

**Conceptualizing Aesthetic Preference.** Neither children nor adults believe that in the case of conflicting aesthetic preferences only one can be right (Kuhn, Cheney, & Weinstock, 2000). This finding was determined by asking children (8-, 10-, 13-, and 17-year-olds) and adults of various education levels to react to pairs of statements about aesthetic preference: one about paintings, one about music, and one about literature (e.g., Robin thinks the first painting they look at is better. Chris thinks the second painting they look at is better. Can only one of their views be right, or could both have some rightness?). Those who said only one could be right were classified as absolutists; at no age, did absolutist views predominate (though these views were more common among 7- to 8-year-olds than among older children). Those who said both could be right were then asked whether one view could be better or more right than the other. Those who replied no were classified as multiplists in the aesthetic domain; those who said yes were classified as evaluativists. Most children and adults were multiplists, believing that two conflicting aesthetic preferences were equally right, thereby failing to distinguish aesthetic judgments from matters of personal taste. Only adults with expertise in the study of epistemology were evaluativists, believing that while both aesthetic preferences could be “right,” one could have more merit than another. Adolescents and adults were more likely to have become evaluativists in other domains than in the domain of aesthetic judgment and taste. Thus, they were more likely to respond as evaluativists when asked about: conflicting value judgments (how bad lying is), conflicting judgments of truth about the social world (causes of crime), and conflicting judgments of truth about the physical world (composition of atoms). Yet, this finding could be a Western phenomenon. If children from a traditional society, such as China, were assessed, perhaps we would find them more likely to believe that one work of art can legitimately be judged as better than another.

**Drawing: Major Milestones in Development**

The milestones in the development of picture production are striking, and the oddities of children’s drawings have been characterized by some as indications of immaturity, but by others as indications that in some ways children are like artists.

**Action Representations**

The first milestone in drawing is the emergence, sometime between the ages of 1 to 2, of the kind of mark making we call scribbling. Using a large sample of preschool drawings, Kellogg (1969) described 20 basic kinds of scribbles (e.g., single curved line, roving open line, multiple loop line, and zigzag) as the building blocks of later representational drawings (but see Golomb, 1981, who was able to identify only two kinds of scribbles—circular loop and whirls, and repeated
parallel lines). According to Kellogg, children use the basic elements of scribbles to make progressively more controlled and complex forms. For example, a vertical and horizontal line together create a cross, which, when enclosed by a circle, becomes a “mandala”; when lines are drawn radiating out from the circle, the mandala becomes a sun or a tadpole human. Kellogg believed that representation emerges only after extensive practice with mark-making and only when adults respond to the child’s “meaningless” forms by pointing out a resemblance to objects in the world (e.g., showing the child how the circle with lines radiating out looks like a person). But studies show that children and adults with no previous drawing experience can, after one or two trials, arrive at drawings of humans that children in our culture achieve only after much practice with scribbling (Alland, 1983; Harris, 1971; Kennedy, 1993; Millar, 1975).

Thus, scribbling may not be a necessary precursor to graphic representation (for a review of these claims, see Golomb, 2004, chap. 1). Figure 20.2 shows the first drawings of a 5-year-old boy from the South American Andes who progressed rapidly to human figures (Harris, 1971).

There is also reason to believe that scribbling itself has representational meaning. According to early views, scribbling (the very name suggests something messy and lacking in purpose) is a nonrepresentational activity that children carry out primarily for rhythmic, kinesthetic pleasure rather than for an interest in the marks they make. Matthews refers to these kinds of early representations as “action representations,” in contrast to later graphic representations where the final marks themselves reveal what they are intended to represent.

Action representations show us that even 2-year-olds grasp the concept that their own drawings are representational (this understanding emerges at about the same time as their understanding that pictures by others are representational, as reviewed earlier). A second indication of such representational awareness occurs when children give their scribbles names (called “romancing” or “fortuitous realism”; Gardner, 1980; Golomb, 2004; Gross & Hayne, 1999; Luquet, 1913, 1927). When asked what they have drawn, children ages 2 to 3 are more likely to give representational meanings to broken (angular) curves but to call smooth lines just “lines” (Adi-Japha, Levin, & Solomon, 1998). This finding may be due to a combination of two factors: (1) Broken curves create somewhat more closed forms; and (2) children may pay more attention to these kinds of lines because as they draw them they have to change direction intentionally. When children were asked to interpret scribbles by peers or their own scribbles produced several weeks earlier, they did not differentiate between types of line in this way. A third indication that 2-year-olds grasp the concept that drawings are representational is that they are able to draw recognizable representations of a human figure when the parts of the figure are dictated to them (called “guided elicitation”) and when asked to complete a partially drawn figure (Bassett, 1977; Cox & Parkin, 1986).

**Graphic Representations**

The first spontaneous graphic representations (ones that depict recognizable objects) emerge in typical children between 3 to 4 years of age (Golomb, 2004). Unlike action representations, graphic representations actually **look like** what they stand for. Even in cultures with almost no pictorial tradition, children make graphic representational drawings when asked by researchers to draw (Alland, 1983). Thus, children do not need to be instructed to arrive at graphic representation, nor do they first need models of representational drawings to do so.

**Representing the Human Form.** One of the first graphic representations children attempt is the human figure (Golomb, 2004). Children’s early attempts to represent the human figure have been described as “tadpoles” because these representations consist of a circle
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Figure 20.3  Action representation of an airplane by a child ages two years and two months. Source: From The Art of Childhood and Adolescence: The Construction of Meaning (p. 34, figure 11), by J. Matthews, 1999, London: Falmer Press. Reprinted with permission of Taylor and Francis Books.

Figure 20.4  (a) Armless tadpole by a child aged three years and three months. (b) Tadpole with legs and arms by a three and a half year old. Source: From The Child’s Creation of a Pictorial World, second edition, p. 29, figures 16a and 16b, by C. Golomb, 2004, Mahwah, NJ: Erlbaum. Reprinted with permission.

Figure 20.5  Drawings by a 4-year-old showing the effect of instructions on presence/absence of arms in tadpoles. Source: From The Child’s Creation of a Pictorial World, second edition, p. 46, figure 25a, by C. Golomb, 2004, Mahwah, NJ: Erlbaum. Reprinted with permission.

with arms and legs (or just legs) emanating from it, as shown in Figures 20.4a and 20.4b. These figures appear to have heads but no trunks (Luquet, 1913, 1927; Piaget & Inhelder, 1956; Ricci, 1887), though Arnheim (1974) argued that the circle represented both head and body.

Children typically draw their first tadpole around 3 years of age (Cox & Parkin, 1986). Some remain in this phase for months, while others pass through this phase rapidly, moving on to more differentiated figures (Cox, 1993, 1997). Though tadpoles appear to have no trunks, Golomb (2004) showed that tadpoles do not reflect a limited understanding of the human body. For instance, when asked to construct a person out of given geometric shapes, only 2 out of 27 3-year-olds made tadpoles; when asked to complete a drawing consisting of a head with facial features, or when asked to model a person out of Play-Doh, many of the same children who drew tadpoles included a trunk. Figure 20.5 shows drawings by a 4-year-old: When asked just to draw a person she drew an armless tadpole (the two figures on the left); when asked to draw a person with a tummy she drew a body (third figure from the left); and when asked to draw a person with a flower, she included a body and an arm. Thus, the task and the medium influence what is drawn. Tadpoles are not a printout of what the child knows about the human body; when it comes to the tadpole, the old adage that children draw what they know and not what they see has no support. They may not draw what they see, but their drawings do not tell us all that they know about what they draw.

According to Freeman’s (1980) production deficit view of children’s drawings, tadpoles are defective not because of the child’s limited knowledge of the human form but rather because of children’s planning and memory deficits. Freeman argues that drawing is a serially ordered performance. When children draw the figure, they begin with the head and end with the legs, forgetting what comes in the middle (trunk and arms), just as when remembering verbal lists we are more likely to remember the first and last word than those in the middle. But there are problems with this performance explanation. Experiments by Golomb and Farmer (1983) show that while children do draw the human starting at the top and moving down, 40% of the 3-year-olds also moved back up, adding arms, facial features, and so on. When asked to list the parts needed to draw a person, children were far more likely to include arms and a trunk than they were when asked to draw a person. When given global instructions (draw a person), 3- to 5-year-olds produced tad-
poles, but when given more specific instructions (e.g., draw a person with a tummy, with a flower), these same children were able to add a torso and an arm (Golomb, 1981, 2004). And when children who spontaneously draw tadpoles were asked to construct a person out of cut out pieces of paper such as circles and rectangles, they often included a torso, showing that they are aware of the torso but just did not know how to include it in their spontaneous drawings (see also Bassett, 1977; Cox & Mason, 1998). Golomb (2004, p. 55) reports cases in which tadpole drawers scrutinized their drawings and criticized them, saying, for example, “The arms are wrong! They go here (points to the shoulders).” These findings fail to support Freeman’s position that failure to remember the trunk and the arms explains why these are omitted from tadpole humans.

Taken together, the evidence shows that defects of knowledge, memory, or understanding do not explain tadpoles. The tadpole is a simple, undifferentiated form that is, in Arnheim’s (1974) terms, a clear structural equivalent for a human reflecting the difficulty of the drawing task, but not reflecting all that the child can do when pushed, prodded, and stimulated by clever tasks and instructions.

Between the ages of 3 to 4.5, as children move from the tadpole to a “conventional” figure with a body differentiated from the head (Cox, 1993), they sometimes draw transitional figures in which the arms are attached to the legs (as in Figure 20.6) and with body features, such as buttons or stomach, sometimes placed between the legs (Cox & Parkin, 1986). The transition from tadpole to conventional figure is variable, with some children passing through a very short tadpole phase, and others spending many months in this phase. Cox and Parkin found that children often produce tadpoles and conventional figures at the same time. While the mechanism of change from tadpole to conventional figure is not clear, it seems likely that children change when they want to make their drawings fit the model more accurately, and not as a function of seeing models by older children or of explicit instruction (Cox, 1993, 1997).

Early conventional figures are sometimes produced by adding a cross-line between the legs of a tadpole, thereby creating a body (Goodnow, 1977). More often, children draw two vertical lines from the head and join them with a horizontal line at the bottom, and then add two legs under this (Cox, 1997). Most, however, draw a rounded body stuck to the head by starting a line from the head and then bringing it back up again, as the 4-year-old did in Figure 20.7.

At first, children add features such as fingers or feet in a segmented manner, giving each body part its own space with no overlapping (Goodnow, 1977). However, after the age of 5 or 6, children become able to draw with a continuous contour line, as illustrated in Figure 20.8, a method referred to by Goodnow (1977) as “threading.” Cox (1993) found in her sample that 26% of 5- and 6-year-olds, 81% of 7- and 8-year-olds, and 96% of 9- and 10-year-olds drew figures with a continuous outline.

Typically, children (at least in the modern West) draw figures in frontal view but when given specific instructions that call for other orientations (e.g., draw a


**Figure 20.7** Conventional figure with head and body differentiated drawn by child aged five years and eight months who started a line from the head and made a loop for the body. *Source:* From *The Child’s Creation of a Pictorial World,* second edition, p. 52, figure 33, by C. Golomb, 2004, Mahwah, NJ: Erlbaum. Reprinted with permission.

man running), many children over five can draw people in profile (Cox, 1993). Figure 20.9 shows a profile drawing by my son at 5 years, 8 months when asked to draw from observation in an art class—he had only a side view of the person he was asked to draw. But even 4-

year-olds make clumsy attempts (e.g., simply leaving out one eye) to alter their figure when asked to draw people from the back or side (Cox & Lambon Ralph, 1996; Cox & Moore, 1994; Pinto & Bombi, 1996).

Realism

Because of the assumption of a universal trajectory from object-centered representation toward viewer-centered optical realism, the dominant question in the study of children’s drawings has been how realism develops. Some researchers have asked why children do not at first draw realistically, using perspective (Costall, 1995). Such a question assumes that perspectival drawings are simply tracings of what we see if we could only look with an “innocent eye,” and that something prevents children from drawing what they see. According to Sully (1895), an early student of child art, “the child’s eye at a surprisingly early period loses its primal ‘innocence,’ grows ‘sophisticated’ in the sense that instead of seeing what is really presented it sees, or pretends to see, what knowledge and logic tell it is there. In other words his sense-perceptions have for artistic purposes become corrupted by a too large admixture of intelligence” (p. 396, cited in Costall, 1995, p. 18). A similar analysis was proposed by Bühler (1930), who believed that verbal labels interfere with the innocent eye. “As soon as objects have received their names, the formation of concepts begins, and these take the place of concrete images. Conceptual knowledge, which is formulated in language, dominates the memory of the child” (p. 114, cited in Costall, 1995, p. 18).

More recently, Freeman (1987) proposed a similar view, based on Marr’s (1982) theory that the initial stages of visual processing give viewer-centered information about the perspectively distorted projected retinal image, followed by a translation into an object-centered description without the distortion. According to Freeman (1987) it is difficult to move from an object-to-a-viewer-centered description, because this requires “actively curbing normal perceptual habits” (p. 147, cited in Costall, 1995, p. 21). In short, knowledge gets in the way.

There is however no good reason to believe that children initially see the world in perspective. According to optical scientist Charles Falco, perspective is an unnatural consequence of a fixed lens locked into position pointing in a fixed direction and projecting an image onto a surface. We do not see in this way. Our eyes are constantly scanning a scene, providing our brains with
anything but a fixed perspective (Falco, personal communication, July 7, 2003). It is difficult to draw in perspective, and perspective was a late development in the history of Western art, made possible by the discovery of rules as well as inventions of external devices (e.g., looking at a scene with one eye through an aperture; viewing a scene with one eye through a plane of glass and tracing the scene on the glass) that help the artist adopt a single vantage point from which to draw (Gombrich, 1977; Radkey & Enns, 1987).

Also mistaken is the assumption that perspectively correct pictures are clearer than any other kind. Many nonperspectival pictures, such as cartoons, caricatures, and children’s drawings, are highly informative because they capture perceptual invariants such as straightness, bentness, perpendicularity, convergence, symmetry, and so on (Costall, 1995; Gibson, 1973, 1979).

The Trajectory from Intellectual to Visual Realism. Luquet’s (1913, 1927) and Piaget and Inhelder’s (1956) claim that children do not draw what they see (visual realism) but instead what they know (intellectual realism), is consistent with a nineteenth-century demonstration by Clark (1897) who showed that 6-year-olds drew an apple with a pin stuck in it so that the pin (which the child knew was inside the apple) was visible inside the apple, which thus appeared transparent. Piaget and Inhelder (1956) demonstrated the same phenomenon by asking children to draw a stick shown either from a side view or a foreshortened end view. Children under ages 7 to 8 drew a line or long region for both orientations. It would have been correct to depict the foreshortened stick as a circle, and circles are just as easy for the child to draw as a straight line, but children’s depictions of the foreshortened stick were presumed to reflect their knowledge that the stick was long.

Do children draw in an intellectually realistic way because their knowledge interferes or because they can’t figure out how to translate a three-dimensional object into a two-dimensional representation? Evidence for the first of these explanations comes from a study showing that when children copied drawings of cubes, they drew much less accurately than when they copied designs, which were matched to the cubes in number of lines and regions (Phillips, Hobbs, & Pratt, 1978). When children knew they were copying a cube, their knowledge that a cube has square faces interfered with realism and they did not distort the faces of the cube by drawing them as parallelograms. Figure 20.10 shows the two models children were given to copy, and an example of an intellectually realistic copy of the cube and a fairly correct copy of the design. The fact that they were copying pictures of cubes rather than drawing from a three-dimensional model shows that in this case intellectual realism was not due to the difficulty of translating a three-dimensional image into a two-dimensional one because the drawing they were copying solved that problem for them. Presumably, their knowledge of a cube’s actual shape interfered. Phillips, Hobbs, and Pratt (1978) suggest that young children have graphic-motor schemata for specific objects (e.g., when drawing a cube, they draw square faces). When they begin to draw a particular object, they select its corresponding schema; the observation of the object being copied then no longer influences the drawing.

There have been many demonstrations consistent with Luquet’s (1913, 1927) original claim of a phase of intellectual realism followed by visual realism. One of the most often cited kinds of examples are X-ray or transparency drawings (Crook, 1984). For other research on children’s development toward visual realism, see Barrett and Light (1976); Beyer and Nodine (1985); Brenner and Batten (1991); Brenner and Moore (1984); Chen (1985); Chen and Cook (1984); Colbert and Taunton (1988); Cox (1978, 1981, 1986); Crook (1985); A. Davis (1985); Freeman (1980); Ingram and Butterworth (1989); H. Lewis (1963); Light (1985);
Light and Humphreys (1981); Mitchelmore (1980); Nicholls and Kennedy (1992); Sutton and Rose (1998); Taylor and Bacharach (1982); Willatts (1985); see Park and I (1995), for a review.

While there is ample evidence for intellectual realism in young children's drawings, we need not conclude that such drawings show us all that children know about the objects they draw. Young children are quite capable of producing viewer-centered drawings under certain conditions. For example, 6-year-olds who did not typically show occlusion were able to do so when they were asked to draw a toy policeman "hiding" behind a wall (Cox, 1981). Light and MacIntosh (1980) showed that when asked to draw a toy behind a glass, children drew the toy and glass side-by-side; when asked to draw a toy inside the glass, children drew realistically. While children under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they are not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they under 7 to 8 draw cups with handles even when the handle is not visible (Freeman & Janikoun, 1972), they.

In considering the development of realistic depiction, it is important to remember that even the most realistic picture contains infinitely less information than does the actual scene (Gombrich, 1977), and thus the creation and perception of pictures both always require ability to infer. Our knowledge of what we are drawing plays some role in allowing us to represent an object pictorially; our knowledge of what is represented in a picture also plays a role in helping us recognize what is represented. As Phillips, Hobbs, and Pratt (1978) point out, recognizing a realistic line drawing of a cube as a solid object requires some measure of what might be called intellectual realism. Our knowledge of what is depicted helps us see the drawing as a cube. There is no pure visual realism operating independently of knowledge.
**Representing Depth.** Some of the studies reported earlier on the transition from intellectual to visual realism have shown children’s difficulty in representing depth. Willats (1977, 1995) uncovered a series of stages that children go through as they acquire the graphic rules for creating the illusion of depth in a drawing. He asked children ages 5 to 17 to draw, from observation, a table with objects resting on it (Figure 20.11a). Five kinds of projective systems and five different sets of drawing rules for mapping objects onto the page were found. Drawings with no projection system were more common among the 5- to 7-year-olds than at older ages (Figure 20.11b). The most common strategy for 7- to 12-year-olds was to draw the table in orthographic projection, in which the tabletop was drawn as a line with objects resting on it, with the third dimension completely ignored (Figure 20.11c). This is a visually realistic way of depicting a table, and captures the view from eye level. The most common strategy for 12- to 13-year-olds was to use vertical oblique projection (Figure 20.11d), which is a system used in Indian, Islamic, and Byzantine art and never taught in Western art classes. Here the vertical dimension on the page represents the third dimension in the scene (vertical lines represent edges receding into depth). Vertical oblique projection allows children to show their knowledge that a table top is rectangular, but the drawing is no longer visually realistic. Moreover, this system results in ambiguity because it does not...
disambiguate between high up versus receding into depth in the actual scene.

Only a minority of 13- to 14-year-olds figured out that one can resolve this ambiguity by using diagonal lines to indicate depth (Figure 20.11f); even fewer at this age drew in true perspective (Figure 20.11g). Consistent with Willat’s findings, early collections of children’s drawings included few perspective drawings even at adolescence (e.g., Kerschesteiner, 1905). Children in our culture do not naturally begin to draw in perspective, even though perspectival images are everywhere. Those who do draw in perspective have probably had training, or they are gifted in the visual arts (for descriptions of children gifted in drawing who figure out perspective early and essentially on their own, see Golomb, 2004, and Winner, 1996). Other studies of children learning to depict depth include Freeman, Eiser, and Sayers (1977); Light and MacIntosh (1980); Phillips, Innall, and Lauder (1985); Radkey and Enns (1987); and Reith and Dominin (1997).

Willats’s stages show the complexity of the development of the ability to represent depth. The stages do not increase linearly in visual realism because the orthographic projections of stage 2 are actually more realistic than the vertical oblique projections that come next. Willats (1977) argued that perspective drawing develops not as a function of increasingly accurate observation of the world or of pictures, but rather due to the desire to reduce ambiguity. This view is consistent with Karmiloff-Smith’s (1992) studies of children’s over-marking in various domains (including drawing) to reduce ambiguity, and would explain the shift from vertical oblique to oblique perspective. Willats (1984, 1995) goes on to argue, in a manner that echoes Luquet (1927), that development away from object- to viewer-centered descriptions occurs as children begin to notice that their drawings do not fully capture how the scene really looks and begin to judge their drawings self-consciously in these terms. Children invent increasingly complex systems when they become aware of the limitations of the system they are using.

**Aesthetic Properties: Expression, Composition, Style, and Color**

We know far less about aesthetic properties of children’s drawings (e.g., expression, composition, style, color) than about representational properties, an imbalance that may reflect the assumption that the end state of visual art is realism.

**Expression.** While preschoolers’ drawings appear expressive to adults, we cannot tell from spontaneous drawings whether the expressive properties are intentional. Some intervention is called for. When children were asked to draw a tree to complete a picture that was either gloomy (e.g., picturing a hunched-over figure with dark clouds overhead) or cheery (e.g., picturing a skipping person on a sunny day), they were unable to add expressively appropriate trees (e.g., drooping or dying tree versus blooming tree) until the age of about 11 (Carothers & Gardner, 1979). This finding would suggest that young children cannot intentionally express moods in their drawings. However, when instructions make it clear that children are to attend to expression, children succeed at a much younger age. This was shown in three studies. Asked directly to make a sad, happy, and angry tree, and a sad, happy, and angry line, even 4-year-olds succeed 37% of the time (Ives, 1984). In a study using equally explicit instructions, Winston et al. (1995) asked children ages 6, 9, and 12 to make a drawing of a tree that showed happiness, and one that showed sadness, adding that it did not matter if the tree looked like a real tree. Half of the children were given only a restricted set of colors (none of which could be used to represent a tree realistically), but all of which had been judged by young children to be either happy (e.g., yellow or orange) or sad (e.g., blue or purple). Children in this restricted condition were also told to make the tree without leaves or flowers, to maximize the chances they would use abstract properties to depict mood (e.g., color, line direction, size, or shape) rather than representational ones (e.g., a dying tree for sadness). Every child was able to use at least one strategy for expression. Older children were more likely than younger ones to
use abstract properties expressively, though in the restricted condition, 6-year-olds used color expressively as often as did the 12-year-olds. Finally, when asked to look at a representational picture showing a person in either a happy, sad, calm, or excited mood, to think about the mood shown (but without being given any verbal labels for the moods), and to select from two abstract pictures the one that was most similar in mood (e.g., happy versus sad for the happy or sad target; calm versus excited for the calm or excited target), children performed above chance by age 4 or 7 (but not by age 3 or 8; Winner et al., 1986).

Thus, we can conclude that when directly asked to show certain very basic moods in their drawings, preschoolers show some ability to do so; by age 6, children reliably show moods in their drawings when asked to do so; and when their color choice is restricted to colors that cannot be used representationally to depict certain objects, 6-year-olds can use the abstract property of color to express moods. These findings are consistent with ones reported earlier showing that preschoolers can, under certain conditions, perceive expressive properties.

**Composition.** Studies of compositional principles in children’s drawings show a development toward order and balance (Golomb, 1987, 2004; Golomb & Dunnington, 1985). Golomb and Farmer (1983) analyzed compositional principles found in over 1000 drawings of about 600 children ranging from 3 to 13 years of age. The most primitive compositional strategy, seen only infrequently in the drawings of 3-year-olds, was an aspatial one in which figures were placed arbitrarily across the page. This strategy was followed by a proximity strategy in which objects were clustered together. Both of these strategies gave way to alignment and centering.

The alignment principle was seen as young as age 3, with objects partially aligned side by side along an imaginary horizontal axis. The alignment is only partial because objects still appear to float about in space. Partial alignment was used by 3-year-olds 55% of the time in Golomb’s (2004) samples. By age 4, figures were aligned carefully and evenly across the horizontal axis. Five- and 6-year-olds continued this strategy, but clearly located the figures at the bottom of the page, with the empty space on top representing the sky, thus defining up and down (see also Eng, 1931).

The centering principle can be seen in drawings of 3-year-olds. The earliest use of centering consists of a single figure placed in the middle of the page. This results in symmetry (recall that by 12 months of age children prefer vertical symmetry over asymmetry; Bornstein, Ferdinandsen, & Gross, 1981). Golomb (2004) found this kind of simple centering in 15% of 3-year-olds’ drawings. By age 4, several figures may be balanced around the center (36% of 4-year-olds’ drawings were centered). By age 5 and 6, symmetry was created by equal spacing of figures and repetition of elements. An increase in symmetry with age was also reported by Winner, Mendelsohn, and Garfunkel (1981).

Balance can also be achieved without symmetry, when different qualities counterbalance each other (e.g., a small bright form may be balanced by a larger pale form because brightness lends weight; Arnheim, 1974). This kind of “dynamic balance” was found by Winner et al. (1981) in 25% of drawings by children aged 4, 6, and 10. In contrast, dynamic balance was seen rarely by Golomb (2004), who found little change in compositional strategies after the ages of 9 to 13, perhaps due to children’s competing interest in realistic depiction.

**Style.** Some children have recognizable drawing styles by age 5. This was demonstrated in a study in which adults judged the similarity relationships among pairs of drawings by three 5-year-old children (Hartley, Somerville, Jenson, & Eliefja, 1982). Their judgments showed that drawings by two of these children were cohesive, meaning they had a distinctive style. Judges were able to recognize new drawings by the same two children drawn at the same time as well as 9 months later. An even stronger demonstration that children have persistent drawing styles was reported by Pufall and Pesonen (2000) who found that adults who learned to recognize the style of three 5-year-olds could identify drawings by these children done 4 years later. But Watson and Schwartz (2000) showed that only about a third of the children in their sample showed a distinctive style, with younger ones (5- to 8-year-olds) showing greater distinctiveness than older children (9- to 10-year-olds). Perhaps this decline is due to drawings in middle childhood becoming conventional, stereotyped, and less playful than those in the preschool years, as is discussed later.

**Universality versus Cultural Specificity of Drawing Schemas**

Many aspects of drawing development appear to be universal and to emerge independently of culture and
formal training (Alland, 1983; Anati, 1967; Belo, 1955; Dennis, 1957; Fortes, 1981; Golomb, 2004; Havighurst, Gunther, & Pratt, 1946; Jahoda, 1981; Kellogg, 1969; Kerschensteiner, 1905; McBride, 1986; Paget, 1932; Ricci, 1887; Sundberg & Ballinger, 1968; B. Wilson & Wilson, 1984). Yet, strong cultural differences in children's drawings also exist. For example, perspective is rarely found in the art of children (or adults) who are not exposed to realistic graphic representations (Golomb, 2002, chap. 4). And schemas for representing particular objects vary across cultures. For example, B. Wilson and Wilson (1981) report that many schemas in children's figure drawings common in the nineteenth century are rarely seen today, a finding which they attribute to the importance of models for children to copy. One such feature is the two-eyed profile. Ricci (1887) found that 70% of Italian children's profiles had two eyes, and half of Sully's (1895) English children's drawings were two-eyed profiles. In the Florence Goodenough "Draw a Man" collection of children's drawings amassed between 1917 to 1923 and housed at Pennsylvania State University, only about 5% were two-eyed profiles. By the 1950s, these figures were nowhere to be seen in American children's drawings. The demise of the two-eyed profile has been attributed to the decline of the profile as the culture's most characteristic pictorial view of the face and the rise of the daily comic strip with figures in every possible orientation (B. Wilson & Wilson, 1981). Wilson and Wilson note many other features that used to be found in children's drawings but are no longer: For example, ladder mouths (where the mouth looks like a horizontal ladder, with the rungs being the teeth), hands like garden rakes, and milk-bottle shaped bodies. Wilson and Wilson predict that future investigators may wonder about the origin and decline of figures with big biceps and capes flying through the air. Children's drawings, Wilson and Wilson remind us, do not emerge from some kind of innate program but instead are heavily influenced by the cultural models available to the child to copy.

The powerful effect of the pictorial culture was also demonstrated by B. Wilson and Wilson (1987) in a comparison between drawings by 12-year-olds from Egypt versus Japan. The Egyptian children were exposed to few pictures and had little arts instruction in school. Their drawings of human figures were static, figures floated in space, and there were only primitive attempts to depict depth. In contrast, the Japanese children were heavily exposed to images in Japanese comic books (and also had a richer arts education). Their drawings of humans looked very much like the images in the comic books that they read: The drawings were dynamic (the figures were depicted in motion), complex (there were many figures), the figures were grounded, and depth was represented through occlusion and size diminution.

Winner (1989) noticed the strong influence on Chinese children's drawings of cartoonlike images published in children's magazines. Wilson (1997) made the same observation about Japanese children who now draw humans with heart-shaped faces and huge eyes, images copied from popular comic books called Manga. Moreover, sequential graphic narratives are far more common among Japanese children (showing the influence of Manga) than they are among Egyptian children (B. Wilson & Wilson, 1987; for other work on cultural influences on drawing, see Andersson, 1995a, 1995b; Court, 1989; Cox, 1998; Cox, Koyasu, Hiranumu, & Perara, 2001; Martlew & Connolly, 1996; Piaget, 1932; Stratford & Au, 1988; B. Wilson & Wilson, 1977, 1984).

**Does Drawing Skill Improve Linearly with Age?**

While all would agree that technical drawing skills improve steadily with age, including the ability to draw realistically, researchers disagree about whether aesthetic properties of children's drawings improve linearly with age. Some aspects of drawing ability have been shown to be U-shaped, declining after the preschool years, only to return again in those children with talent and interest in drawing. Resemblances between the art of twentieth-century masters and drawings by young children (in terms of playfulness, simplicity, expressivity, and aesthetic appeal) have been noted (Arneheim, 1974; Gardner, 1980; Hagen, 1986; Schaeffer-Simmern, 1948; Winner & Gardner, 1981).

Children draw less frequently as they grow older (Cox, 1992; S. Dennis, 1991; Golomb, 2002) and drawings become conventional and lose their playfulness by age 9 or 10 (Gardner, 1980). A similar decline has been reported in the domain of metaphor (Winner & Gardner, 1981): Understanding of metaphor improves linearly with age, but the willingness to play with language and create metaphors dips in the middle school years, giving way to a desire to use words in a literally correct manner.

Support for the observation that the playful aspects of drawing decline with age during the literal stage, but emerge again in adolescence, comes from a study show-
ing that young children are more willing to violate realism than are older children (Winner, Blank, Massey, & Gardner, 1983). Children ages 6 through 12 were given copies of black-and-white line drawings by artists varying in level of realism (e.g., a realistic Picasso versus a nonrealistic Picasso) and each with a small portion of the drawing deleted. Children were asked to finish the drawings the way the artist would have done. When the drawings were representational, children were told to add the “hair” or the “arm” and were shown where the drawing was incomplete. Responses were scored by whether the level of realism in the drawing was matched in the completion. Six-year-olds performed better than both 8- and 10-year-olds and did as well as the 12-year-olds. Thus, for example, 6-year-olds completed a schematic, nonrealistic Picasso drawing with a missing arm by adding an arm with a nonrealistic, schematic hand; they completed a realistic Picasso, also with a missing hand, with a far more realistic hand. In contrast, 8- and 10-year-olds completed all works in an equally realistic way. They were preoccupied with trying to draw realistically and thus were unable or unwilling to draw nonrealistically even when this tactic was called for by the criterion of stylistic consistency. Because the 6- to 12-year-olds performed equally well and better than the 8- to 10-year-olds, the willingness to violate realism was found to be U-shaped.

J. Davis (1997) provided the strongest evidence for U-shaped development in drawing. She elicited drawings by the following groups: Those presumed to be at the high end of the U-curve in aesthetic dimensions of their drawings (5-year-olds), those presumed to be in the depths of the literal, conventional stage (8-, 11-, 14-year-olds and adults, all nonartists), and those presumed to have moved beyond the literal stage (14-year-old self-declared artists and professional adult artists). Participants were asked to make three drawings under the following instructions: Draw happy, draw sad, and draw angry. Judges blind to group scored the drawings for overall expression, overall balance, appropriate use of line as a means of expression (e.g., sharp angled lines to express anger), and appropriate use of composition as a means of expression (e.g., asymmetrical composition as more expressive of sadness than a symmetrical composition). The results were clear: Scores for the adult artists’ drawings were significantly higher than scores for the works of children ages 8, 11, 14 (nonartists) and adults (nonartists), but did not differ from the scores of two other groups—the youngest children (age 5) and the adolescents who saw themselves as artists. Thus, only the 5-year-olds’ drawings were similar to those by adult and adolescent artists, revealing a U-shaped developmental curve for aesthetic dimensions of drawing. While the adult artists often depicted a mood through nonrepresentational drawings, all but one of the 5-year-olds drew representational works. Thus, artists and young children used different means to achieve equally clear expression.

Pariser and van den Berg (1997) countered that the U-shaped curve is culturally determined—a product of the Western expressionist aesthetic. They found that while Westerners judged preschool art as more aesthetic than that of older children, Chinese American judges, influenced by their own more traditional, nonmodernist artistic tradition, awarded higher scores to older than younger children’s art. This finding, if replicated in other studies, shows that the U-curve is a manifestation of how we judge children’s art, and could be a product of a Western modernist expressionist aesthetic.

The loss of interest in drawing, and the loss of expressiveness in drawing (as perceived by Westerners) in the middle childhood years, may not be inevitable. Arts education plays a very small role in our schools. It is certainly possible (though yet untested) that if the visual arts were taught seriously throughout the school years, no decline in interest or expressiveness would be found.

MUSIC

Music is a near-constant presence in our lives, whether on the radio, TV, elevator, or concert hall, and almost all people love some kind of music. While we may not be able to talk explicitly about what it is that we hear when we listen to music, we have a great deal of implicit knowledge about music, based on certain innate sensitivities (to be discussed later) and years of exposure to the music of our culture.

Because almost all of the developmental research on music has been conducted on Western children exposed to Western tonal music, we know little about development in non-Western musical traditions. However, many musical universals exist. For example, all cultures have a systematic way of organizing pitches that repeat over octaves, and all scales have a limit of about seven pitches within an octave (Dowling & Harwood, 1986). Individuals from different musical traditions share the ability to perceive notes separated by octaves as equivalent (octave
equivalence); and there is a weaker tendency to perceive the perfect fifth as having a special status (Dowling, 1991). Almost all scales divide the octave into five to seven pitches with unequal steps between them (A to A sharp is a half step, A to B is a whole step; the Western diatonic major scale is made up of seven notes; Sloboda, 1985). This property, which leads to a sense of motion and rest or tension and resolution is not found in the regularity of chromatic scales, which have 12 equally spaced notes (and in which, therefore, every tone has equal status), and might account for why chromatic scales have never been widespread (Shepard, 1982).

Although musical universals exist (as do universals in drawing), we also know that exposure to the music of one’s culture has a profound effect on musical development. Western music, whether folk, rock, classical, or songs sung to infants, consists of a fairly small set of musical relationships, which form the basis of all of our music, and from which composers often deliberately deviate to create tension and affect (Lerdahl & Jackendoff, 1983; Meyer, 1956, 1973). How we hear music is constrained by our years of exposure to these basic relationships. Adults in Western culture have internalized tonal structure and tonality organizes our perception of music (D. Bartlett, 1996; Dewar, Cuddy, & Mewhort, 1977; Frances, 1988; Krumhansl, 1979; Lipscomb, 1996). For example, the major scale is the most common structure found in Western European music, and Western listeners find it easier to recall melodies in the major scale than in any other kind of scale (Cuddy, Cohen, & Mewhort, 1981).

### Evolutionary Base

Evidence of music making exists in every known human culture, from hunter-gatherers to industrial cultures (Miller, 2000). Evidence that Neanderthals had music comes from the discovery of a flute carved out of the bone of a bear and dated between 42,000 and 82,000 years ago (Wallin, Merker, & Brown, 2001). This bone had three holes, with the distance between the second and third hole twice that of the distance between the third and fourth, indicating that this flute played music based on the Western diatonic scale. We should not be too quick to conclude from this discovery that the diatonic scale is the most “natural,” however, because other scales could certainly have been used by Neanderthals or early humans.

Some have argued that music evolved for mate selection (Miller, 2000) or for group cohesion (Hagen & Bryant, 2003). Scholars may never resolve the question of whether music is a complex adaptation that occurred during evolution (Miller, 2000) or a by-product of other abilities that themselves evolved for adaptive purposes (Hauser & McDermott, 2003).

Comparative studies of musical abilities in nonhumans can help to clarify the evolutionary history of music. Here we must make a clear distinction between music production (either singing or with instruments) and music perception. No nonhuman primates sing (Hauser & McDermott, 2003), although one (Kanzi, a bonobo) showed controlled drumming on an object and bobbed his head rhythmically as he drummed (Kugler & Savage-Rumbaugh, 2002). Aside from Kanzi, the only nonhumans known to produce music are birds and bird-song is far more constrained than is human music (Hauser & McDermott, 2003).

With respect to music perception, some striking similarities have been found between human and nonhuman primate abilities. Wright, Rivera, Hulse, Shyan, and Neiworth (2000) trained rhesus monkeys to make same/different judgments of melodies and found that they treated a melody as the same when it was transposed by 1 to 2 octaves in the same key. However, if the transposition was only half or one and a half octaves from the original, the transposition (which was then in a new key) was not heard as the same as the original. This finding shows that monkeys hear two Cs as the same, even though they are separated by eight notes (octave generalization), but they hear a C and a G as different even though they are closer on the scale. Wright et al. also found that the perception of similarity between two notes an octave or two apart occurred only when the notes were part of melodies based on the diatonic scale, and not when atonal melodies were used (melodies whose notes are chosen from the 12 tones of the chromatic scale). We can conclude that nonhuman primates are sensitive to tonality and octave relationships (and we will see that human infants are as well).

Although monkeys show a humanlike sensitivity to musical structure, they do not create music. Hauser and McDermott (2003) argue that this frees us from the burden of explaining the evolutionary function of music. Human musical capacities (or at least some of them) may not have evolved as a special music faculty but instead may have drawn on auditory sensitivities that
evolved for other purposes. Domain-general auditory capacities likely evolved before humans began to make music, and at least some basic human musical capacities depend on these more general auditory capacities. The same kind of argument holds for speech perception: Chinchillas perceive some speech sounds categorically, as do human infants, and from this it has been argued that the mechanisms underlying speech perception originally evolved for auditory perception and were later co-opted for speech perception (Hauser, Chomsky, & Fitch, 2002).

Hauser and McDermott (2003) suggest that the human music faculty may also have co-opted another mechanism for music—the mechanism by which human and nonhuman animals express emotion via vocalization, and the sensitivity that young children have to the emotional message in others’ voices. Sensitivity to rhythm may also have evolved for nonmusical reasons. Ramus, Hauser, Miller, Morris, and Mehler (2000) showed that human infants and cotton-top tamarin monkeys could discriminate Dutch from Japanese sentences (languages that have different rhythmic properties). Thus, the ability to perceive rhythm may initially have served purposes other than musical or linguistic ones (given that monkeys have neither music nor language).

**Historical and Theoretical Approaches**

After von Helmholtz published *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (1877), interest in the acoustics of music was sparked. Perhaps the most influential early music psychologist in the United States was Seashore (1919, 1938). Other early music psychologists included Farnsworth (1928), Mursell (1937), Révész (1954), Stumpf (1883), Valentine (1962), and Wing (1968).

Early music psychologists conflated music perception with acoustics. They focused on the measurement of individual differences in musical aptitude, and numerous tests of musical aptitude were developed (for a review, see Shuter, 1968, chap. 2). The publication of the *Seashore Measures of Musical Talent* (Seashore, 1919) was a seminal event in the psychology of music, offering the possibility of assessing musical ability in children and adults primarily through degrees of acoustical discrimination (e.g., determining which of two tones is higher or louder, or which note in a melody has been altered). Seashore assumed musical ability to be unaffected by training and to be adequately measured by acoustical tests, views criticized by Farnsworth (1928) and Mursell (1937).

Validity problems with the Seashore measures were noted by Mursell (1937), who found that they did not correlate highly with independent measures of musicality (defined as being in the advanced orchestra in school). This lack of validity did not surprise Mursell because he reasoned that people with good pitch discrimination skill are not necessarily musical. He criticized the atomistic approach underlying these measures. For example, it is quite possible for an individual to hear a melody as changed yet be unable to say which note was altered. Mursell also criticized the Seashore measures for focusing primarily on acoustic properties of music and on sensory capacities, ignoring important musical concepts such as the feeling of resolution when a piece ends. “Music... depends on the mind and not on the ear,” Musell wrote (p. 57). Mursell called for the development of tests of musical aptitude that assessed judgments of rhythmic and tonal relationships (rather than sensory response to isolated elements) as well as affective responsiveness to music. Révész (1954) also pointed out that musical aptitude is not simply an aggregation of acoustical skills.

Since the cognitive revolution in psychology, with its focus on universal mental structures, music psychologists have turned their attention away from tests of individual differences to the search for universal principles of music perception. Psychologists of music have also begun to connect their work closely to the work of music theorists. Cook (1994) links the relationship between music theory and psychological studies of music to the work of music theorist Meyer (1956). Music theorists have developed models of musical grammar, which offer predictions for cognitive psychologists to test, with perhaps the most influential model being the grammar of music initially proposed by Lerdahl and Jackendoff (1983). For reviews of theory driven research in the cognitive psychology of music with the goal of determining the mental structures involved in the perception and interpretation of music, see Deutsch (1982) and Sloboda (1985).

Early developmental research in music consisted primarily of descriptive studies including case studies (e.g., Gesell & Ilg, 1946; Moorhead & Pond, 1978). For example, describing age norms in responses to music, Shinn (1907) reported that children show pleasure at
music at around 6 weeks, and Shirley (1933) noted that children are calmed by music between 12 to 32 weeks of age. For a review of early studies, see chapters 5 and 6 in Shuter (1968).

One of the earliest theory-driven approaches to the developmental psychology of music analyzed children’s music perception in the framework of Piagetian theory (e.g., Pflederer, 1964; Serafine, 1980). These researchers tried to equate the perception of invariance in music with conservation and hence with concrete operations. In the past few decades, research in the developmental psychology of music has become motivated less by developmental theory than by theories in the cognitive psychology of music.

The new cognitively driven research in the psychology of music (including developmental music research) has not been immune from controversy (see Cook, 1994, and Sloboda, 1985, pp. 151–154). Some have argued that psychologists have too quickly assumed psychological reality for abstract grammars proposed by music theorists in their analysis of music. For example, Cook (1994) argues against the idea of music grammars analogous to linguistic grammars, pointing to evidence that music is more “fluid” than language, and less rule-bound.

Another controversy concerns the use of experimental materials that are short, artificial, and musically impoverished. Sloboda (1985) reminds researchers that in real pieces of music, musical events distant from one another in time may still be closely related. Just as the linguistic study of isolated sentences cannot tell us how we respond to conversations or stories, so the study of short musical fragments (e.g., an interval or a phrase) or isolated musical elements (e.g., pitches or rhythms without melody) cannot tell us about mental activity as we listen to an actual piece of music. The use of short fragments leads us to conclude that music perception is more precisely and analytically rule-governed and less fluid and holistic than it actually is (Cook, 1994). For example, short fragments that do not return to the tonic or the home key sound unfinished; but long pieces of music may well return to the home key and yet do not sound unfinished Cook (1994). Aiello (1994) calls for more naturalistic studies of how we perceive entire pieces of music as the music unfolds, and reviews several recent studies that do just this. Developmental studies of music perception that are more naturalistic will likely be the wave of the future.

Much of the research reviewed later is subject to the criticisms that the materials on which its conclusions are based are far from real pieces of music. Similar criticisms—that the stimuli and tasks used are too artificial—have been leveled at studies of children’s drawings (Golomb, 2004, p. 40). Yet, hypothesis testing often requires the use of somewhat impoverished stimuli. The tension between those who do experimental versus naturalistic studies can be found in all areas of psychology.

Music Perception and Comprehension: Major Milestones in Development

While the ability to produce music shows wide variation, with some individuals demonstrating more talent than others, all normal humans have a considerable implicit understanding of music. And infants show an impressive perhaps inborn ability to process some (but not all) of the complexities of music.

The lullabies that adults sing to babies have universal properties across cultures, and these may influence early music perception skills. Infants show certain kinds of very early sensitivities to music. These include sensitivity to relational rather than absolute properties of melody and rhythm; sensitivity to unequal step structure in scales, a property that characterizes all scales whether Western or non-Western; sensitivity to certain prototypical structures of Western music; and preference for consonance over dissonance.

Other aspects of music perception develop only in the preschool years or later. These include sensitivity to diatonic tonal structure, sensitivity to key changes, sensitivity to the hierarchy of notes within a key, sensitivity to mode (major versus minor and the emotional connotations of each); and sensitivity to invariant structure. These later developments all involve the ability to go beyond the information given to infer a structure that is not literally present. Western children’s sensitivity to these higher order properties of music very likely depends on years of exposure to Western music. Whether we are universally predisposed to acquire the structures used in Western tonal music, or whether we could as easily become acculturated to atonal music, is a question for future research.

Infant Music Perception: Sensitivity to Simple Musical Structures

In many ways, infants process music in an adultlike fashion, suggesting that the ways in which music is processed is biologically constrained and innate. These findings, reviewed here provide support for Meyer’s
known cultures, children are exposed to music from universal properties, they are also exposed to child-predispositions in primates in the wild (not exposed to music in utero and from the 1st day they are born, experience may play a role. Even studies that examine primate musical predispositions are not immune from this possibility because primates may be exposed to music in the lab from radios (Hauser & McDermott, 2003). Only if we can demonstrate humanlike musical predispositions in primates in the wild (not exposed to music) or identical musical predispositions in infants in cultures with entirely different musical traditions can we make the strong argument that certain musical predispositions are inborn and require no musical experience for them to become manifest. This research remains to be carried out.

Music processing in infancy is analogous to speech processing in several ways: (a) Infants must process complex sound patterns with affective rather than referential meaning; (b) there are special forms of music and speech directed to infants; and (c) infants’ lack of acculturation allows them to make certain discriminations in music and speech that adults fail to make, as shown later (Trehub, Trainor, & Unyk, 1993).

Universals in Songs Sung to Infants. In all known cultures, children are exposed to music from early on, particularly in the form of songs sung to them by adults (Trehub & Schellenberg, 1995). Just as infants are exposed to child-directed-speech with certain universal properties, they are also exposed to child-directed-songs with universal properties. The types of songs infants hear are lullabies and “play songs” (Trehub & Trainor, 1998). Much like infant-directed speech, songs directed to infants in Western and non-Western cultures have certain characteristic and universal features that cut across musical traditions. These features are seen when the songs are sung by mothers, fathers, and even preschoolers.

Songs directed to infants are soothing: They are repetitive and have simple, descending contours. Unlike classical Western music or adult Western folk songs, Western nursery songs almost all remain in the same key. Dowling (1988) demonstrated this by coding 223 nursery songs, 317 folk songs, and 44 of Schubert’s songs in terms of whether they contained a key shift. Almost none of the nursery songs, almost half of the adult folk songs, and almost all of Schubert’s songs contained a key shift. Nursery songs repeat strongly tonal patterns and thus may be particularly helpful for Western children’s learning of the Western tonal scale system (Dowling, 1988). Songs directed to infants are higher in pitch, slower in tempo, and more emotionally expressive than songs directed to older children or to adults (Bergeson & Trehub, 1999; Trainor, Clark, Huntley, & Adams, 1997; Trehub, Unyk, & Henderson, 1994; Trehub, Unyk, Kamenetsky, Trainor, Henderson, & Saraza, 1997; Trehub, Unyk, & Trainor, 1993a, 1993b). Mothers’ singing is stable, almost ritualized: When they sing the same song to their infants, the pitch level, and tempo remain practically unchanged (Bergeson & Trehub, 2002).

These aspects of infant-directed songs are perceivable by adults. Adults can distinguish lullabies from nonlullabies matched in tempo even when these come from unfamiliar cultures (Trehub, Unyk, & Trainor, 1993a). Adults can even distinguish songs actually sung to infants from the same songs sung by the same singers pretending to sing to an infant. This finding holds for musically untrained as well as foreign adults, suggesting the existence of universal features of songs sung to infants (Trehub, Unyk, Kamenetsky, et al., 1997).

The universal aspects of songs sung to babies capture babies’ attention. Infants listen longer to songs in the maternal style than to songs sung by the same singers in their usual style (Masataka, 1999; Trainor, 1996) and prefer higher to lower pitched versions of songs (Trainor & Zacharias, 1998). Infants also pay more attention to videotapes of their mothers singing than tapes of them speaking (Nakata & Trehub, 2000). These attention-getting universal aspects of songs sung to infants probably help to mold infants’ musical sensitivities.

Relational Processing of Rhythm and Melody. Like adults, infants perceive rhythms and melodies as coherent patterns rather than sequences of unrelated sounds (Dowling, 1978; Trehub, Schellenberg, et al., 1997). For instance, 7- to 9-month-olds perceive simple rhythmic patterns differing in speed as the same rhythm—they recognize the rhythm despite the change in speed (Trehub & Thorpe, 1989). Chang and Trehub (1977b) demonstrated a similar capacity in 5-month-olds.

Relational processing also occurs for melodies. Contours—the pattern of ups and downs in a melody—are defining properties of melodies for adults (Dowling & Fugitani, 1971) and for infants (Dowling, 1999; Trehub,
Infants perceive two melodies as the same when one is transposed to a new octave, as long as the relations among tones (and hence the melodic contour) are maintained. For example, 6-month-olds were habituated to a 6-note melody and then exposed to a key transposition either with or without the contour maintained (Chang & Trehub, 1977a). In both cases, the transposition contained all new notes. Infants dishabituated only to the contour-altered transpositions. Because the initial and transposed tune shared contour but not notes, the infants must have “recognized” the melody. Infants are sensitive to alterations in contour, noticing them even when the task is made difficult by inserting distractor tones in between the target and comparison melody (Trehub, Bull, & Thorpe, 1984). Thus, in both rhythm and melody, infants perceive simple musical gestalts, whether these be rhythmic groupings or melodic contours.

Infants are sometimes able to recall absolute rather than relative information when it comes to pitch (Saffran, 2003; Saffran & Griepentrog, 2001). When presented with a target and comparison melody that have the same key or same initial pitch, infants react to pitch changes (Lynch, Eilers, Oller, & Urbano, 1990). For example, when they hear a melody containing a G sharp and then a comparison melody identical except that the G sharp has been replaced by G, infants note the change from G sharp to G and revert back to focusing on relational aspects of the melody (Cohen, Thorpe, & Trehub, 1987).

Studies claiming a dominance of absolute over relative pitch processing in infancy are based on short-term memory. When 6-month-olds listened to melodies over a period of days they could not tell when the melodies were transposed to a new key and thus recalled relative rather than absolute pitch intervals (Platinga & Trainor, 2002, cited in Trehub, 2003, in press). Storing the relational information is a far more manageable feat of long-term memory than storing separate pitches.

Infants grasp other kinds of structures in music as well as rhythmic and melodic ones, as shown by their greater reaction to structure-violating changes than to structure-preserving changes. For example, when infants repeatedly heard a six-note sequence (e.g., AAAAAE, with A and E one fifth apart), and then heard the same sequence with a temporal gap, they noticed the gap only when it occurred within (AAAAEE) but not between (AAAEE) groups (Thorpe & Trehub, 1989; see Dowling, 1973, for this finding in adults). And infants also perceive phrases as wholes, as shown by Krumhansl and Jusczyk (1990) who reported the finding that 4- and 6-month-olds prefer to listen to Mozart when pauses are inserted between rather than within musical phrases. Parallels to speech processing are clear, because infants notice pauses within rather than between sentential clauses (Kemler Nelson, Hirsh-Paskek, Jusczyk, & Wright Cassidy, 1989) and are sensitive to melodic contours of speech (Fernald, 1989).

**Sensitivity to the Unequal-Step Structure of Musical Scales.** As mentioned, almost all music has scales with unequal steps between pitches. Can infants distinguish between scales with unequal steps and artificial scales with equal steps? Trehub, Schellenberg, and Kamenetsky (1999) played one of three types of scales to adults and 9-month-olds: (1) the familiar (unequal step) major scale; (2) an artificial major scale with unequal steps, created by dividing the octave into 11 equal steps and selecting seven tones separated either by one or two units; and (3) an artificial equal-step scale created by dividing the octave into seven equal steps. The task was to detect a note that was out of tune. Adults had no difficulty with the major scale, but performed equally poorly on the two artificial scales. Infants did as well on the familiar as the artificial major scale (both have unequal steps). These findings show that unequal step scales are easier to process than are equal step scales. The fact that infants did as well on the artificial major scale shows that their performance with the familiar major scale was not due to familiarity but rather to its unequal step property. The fact that adults performed poorly on the artificial unequal step scale suggests that their initial predispositions were overridden by years of listening to the scales of their culture.

**Sensitivity to “Good” Melody Structure or “Good” Intervals.** Infants show better processing for melodies that Western music theory considers well-structured. Cohen et al. (1987) showed that 7- to 11-month-olds were better able to detect a semitone change in a transposition of a melody if the transposition resulted in a well-structured melody based on the major triad (CEGEC) than if it resulted in a less well-structured melody based on the augmented triad (CEGsharp EC). Similarly, Trehub, Thorpe, and Trainor (1990) found that
7- to 10-month-olds detected a semitone change (in a transposition) only when the original melody was a "good" Western melody in which all the notes belonged to a major scale (in contrast to a "bad" Western melody with notes not in any scale or to a non-Western melody with intervals less than one semitone apart). And Trainor and Trehub (1993) showed that infants have a processing advantage for transpositions related by a perfect fifth. The most likely explanation for infants' better performance with certain types of melodies and intervals that are privileged in Western music is that these infants have already acquired a sensitivity to Western musical structure. Yet, we cannot rule out the possibility that certain structures in Western music are intrinsically easier to process than are violations of these structures. To test this, we need to administer these same tasks to infants from a culture whose music does not follow these structures.

Preference for Consonance. Intervals separated by one semitone (e.g., a "second" such as A and B) sound dissonant; those separated by two semitones (e.g., a "third" such as A and C) sound consonant. Pythagoras showed that consonant combinations of tones have different frequency ratios than do dissonant combinations (e.g., the consonant octave has a frequency ratio of 2:1; the dissonant tritone has a frequency ratio of 45:32; Plomp & Levelt, 1965). Intervals related by simple ratios have more overtones in commons than do intervals related by complex ratios. Consonant intervals such as octaves and perfect fifths have a special status in much of the world's music (Frances, 1988; Schellenberg & Trehub, 1996; Trehub, Schellenberg, & Hill, 1997), and studies show a preference for consonance over dissonance in early infancy.

Zentner and Kagan's (1996, 1998) research confounded consonance with pitch distance (the consonant intervals were wider), but a study by Trainor and Heinmiller (1998) kept interval size constant and again reported a preference for consonance. Six-month-olds heard consonant intervals (e.g., perfect fifths or octaves) and dissonant intervals (e.g., tritones or minor ninths). The infants controlled listening time by their looking behavior, and they looked longer to the consonant intervals. In a second experiment, 5- and 6-month-olds heard a Mozart minuet played as Mozart had composed it as well as a dissonant version of the minuet in which the Gs and Ds were changed to G flat and D flat. Again infants listened longer to the consonant versions.

Preference for consonant over dissonant intervals has been shown in even younger infants though the results were not clear-cut. As in the study by Trainor and Heinmiller (1998), Trainor, Tsang, and Cheung (2002) played consonant chords (perfect fifths and octaves) and dissonant chords (tritones and minor ninths) to 2- and 4-month-olds who could control how long the sound lasted by looking behavior. When infants heard consonant chords first, there was a near-significant tendency for them to look longer to the consonant trials. But when they heard the dissonant chords first, they did not look longer at consonant trials. Trainor, Tsang, and Cheung (2002) suggest that perhaps the dissonant chords displeased the infants so much that they did not resume interest when the consonant chords were played next (see also Trainor & Trehub, 1993; Trehub, Thorpe, & Trainor, 1990).

Numerous other studies have also shown a preference for consonant over dissonant intervals in infancy. For example, infants as young as 6 months detect quarter semitone changes in intervals when the first interval heard is an octave, a "perfect fifth," and a perfect fourth (Schellenberg & Trehub, 1996), but they cannot detect such subtle changes when the first interval heard is a tritone, a chord considered to be unpleasing and nonharmonious. And octave intervals, the most consonant of all intervals, are clearly perceived by infants. Like adults, infants perceive octave equivalence of pitch: They can tell the difference between a pair of tones separated precisely by one octave versus a pair separated by almost an octave (Demany & Armand, 1984).

Whether perception of consonance as more pleasant than dissonance is inborn and a function of the human auditory system, as von Helmholtz (1877) believed (see...
also Plomp & Levelt, 1965; Tramo, Cariani, Delgutte, & Braida, 2001), or whether such judgments are due only to the greater familiarity of consonance given its special status, could be determined by examining infants’ judgments prior to any music exposure. However, because infants hear music in utero, this study would be difficult to carry out and has not been done. Instead, we must make inferences from studies of infants several months old and we cannot rule out the effects of exposure on any kind of outcome. We can also look to animal studies. One study showed that rats develop a preference for consonance over 3 weeks (Borchgrevink, 1975, reviewed in Zentner & Kagan, 1998). However, this preference emerged only after exposure and thus cannot illuminate the question of whether a preference for consonance is innate in rats, much less in humans.

Researchers should be careful not to draw the conclusion that infants’ preference for consonance explains why adults have difficulty making sense of atonal music (e.g., the music of Schoenberg) in which dissonance is prominent. The kind of dissonance in atonal music is far more subtle and complex than that which is created by simply playing two adjacent notes at the same time, and the perception of dissonance in atonal music results from the context in which the interval is heard (Cazden, 1980). In addition, experience may be able to override the perception of dissonance as unpleasant: In one part of Bulgaria, singing in parallel seconds (which sounds dissonant to Western ears) is common in songs with two voices, with the lead singer remaining above the other (Sadie, 1980).

Post-Infancy: Sensitivity to Higher-Level Musical Structures

Although infants display an impressively adultlike response to simple musical structures, there are developmental changes still to occur. Whether these changes are a function of age or of years of exposure to Western music cannot be determined because we lack developmental studies of Western children’s perception of music from cultures with nonwestern musical traditions.

Sensitivity to Diatonic Structure. Almost all Western tonal music (e.g., not only classical but also folk, jazz, and rock) is written within a particular key. Though Western music typically modulates from one key to another over time, at any point in time tonal music is made up primarily of the notes of a particular scale. In the context of a given key, the notes of a scale are perceived as closely related and tones outside of this key sound less related. The relationship among the seven notes of a key is referred to as “diatonic structure.”

In tonal music, the notes in a key have varying functions. The first note of the scale is called the tonic (e.g., in the key of G, the tonic is G). The tonic is heard as the most stable note in a tune and as the central tone toward which the others are drawn (Krumhansl, 1979). Melodies often end on the tonic, resulting in a feeling of stability. If the tune ends on the second note of the scale, it feels incomplete, hanging in midair and unresolved.

As a piece modulates from one key to another, the tonic or tonal center also shifts. In twentieth-century Western atonal music, there is neither key nor tonal center. Atonal music lacks the organizing framework provided by a key because the notes are not limited to one scale (Krumhansl, 1979).

The importance of tonality in organizing adults’ perception of music has been demonstrated. Adults can distinguish tonal from atonal music (Dowling, 1982), and they recall tonal melodies better than atonal ones (Cuddy, Cohen, & Miller, 1977; Dewar, Cuddy, & Mewhort, 1977; Krumhansl, 1979). The ability to hear tonal structure (which is an abstraction) is critically important to understanding music, but the ability to distinguish tonal from atonal music is not present in infancy. Zenatti (1969) showed that by age 6 (but not before), children recall tonal sequences better than atonal ones. Children heard tonal and atonal melodies of three, four, and six notes followed by a comparison melody with one of the notes altered by one or two semitones. The task was to indicate which note had been changed. When the melodies had only three notes, 5-year-olds performed the same (and above chance) for both tonal and atonal melodies. By age 6, children performed better on tonal melodies, showing that they had acquired Western scale structure. By age 12, performance on atonal melodies improved and the tonal melodies did not facilitate performance. However, when the melodies were four or six notes long, the tonal framework remained easier even for adults.

Support for the claim that sensitivity to tonality is a late development (and one that is enhanced by formal training) comes from Morrongiello and Roes (1990). In their study, 5- and 9-year-olds heard brief (nine note) tonal and atonal melodies and then selected the line drawing that matched each melody’s contour. Superior
performance for tonal over atonal melodies was found only for 9-year-olds. Those 9-year-olds who had formal music training (on average, 3 years) distinguished more strongly between tonal and atonal melodies than did those without formal training. Nonetheless, even those with no formal training performed better on the tonal melodies.

In a related study, Trehub et al. (1986) compared children’s discrimination of pitch changes within diatonic melodies (e.g., C-E-G-E-C) versus nondiatonic melodies (e.g., C-E-G#-E-C). Performance of 4- to 6-year-olds was better in the diatonic condition, but infants performed the same in both conditions. Thus, by the age of 4, familiarity with Western music has heightened children’s sensitivity to tonality. Another study suggests that glimmerings of sensitivity to the Western diatonic scale may occur by 12 months of age. Lynch and Eilers (1992) tested the ability to detect changes in intervals in the same simple diatonic and nondiatonic melodies used by Trehub et al. (1986). Infants heard the melodies and their transpositions, some of which contained altered intervals. At 6 months, detection of interval changes was identical across conditions (but above chance). By 12 months, performance was better in the diatonic melodies.

**Sensitivity to Key Changes.** Perception of key is also late to develop. Trainor and Trehub (1992) investigated the ability to detect changes in melodies when the altered pitch was either within or outside the key of the melody. Adults found changes that violated key much easier to detect than ones that remained within key. But 8-month-olds not only performed identically in both conditions (showing a lack of sensitivity to key) but also performed better than adults in detecting within-key changes. Thus, years of listening to Western music impose a structure on what adults hear, such that note changes that remain in key are not heard as changes.

By age 5, children can distinguish keys that are tonally near versus far, a distinction that is independent of geographical distance, because geographically near keys (e.g., C and D) are more remote than tonally near keys (e.g., C and G). J. Bartlett and Dowling (1980, Experiment 4) played children and adults a melody followed by either a transposition or a same-contour imitation, either in a key near to the original melody (and hence sharing many pitches) or in a key far from the original melody (sharing few pitches). Adults heard the transpositions as the same as the original melody, and the same-contour imitations as different. Five-year-olds responded in terms of key: Near key changes (whether transpositions or same-contour imitations) were heard as the same as the original melody, far key changes as different. Thus, 5-year-olds could distinguish near from far keys but could not detect interval size changes when the contour was preserved. By age 8, children were more likely to hear a far-key transposition as the same, and a near-key imitation as different, showing that, like adults, they attend both to key distance and interval changes.

**Sensitivity to the Hierarchy of Notes within a Key.** Children show a growing awareness of the proper structure of melodies (in Western tonal music), recognizing the importance of the tonic note for the ending of a melody. Krumhansl and Keil (1982) asked children to judge the goodness of six-note melodies that began with the tonic triad (C-E-G) and ended on a randomly chosen pitch. When adults were asked to judge the goodness of the final note, notes that are part of the tonic triad (C-E-G) were more highly rated than notes that are outside this triad (Krumhansl, 1990). However, 6- and 7-year-olds only distinguished between endings that were within key versus outside of key. Only by ages 8 to 9 did children begin to distinguish among the pitches of the key, ranking those in the tonic triad as better endings than other notes. When the task was simplified by using five- rather than six-note melodies, sensitivity to this hierarchy of notes within the scale was found by ages 6 to 7 (Cuddy & Badertscher, 1987; see also Sloboda, 1985, pp. 211–212).

The diatonic tonal scale, with its key structure and its hierarchy of notes, is specific to Western tonal music. Thus, it is not surprising that sensitivity to tonality is a late development. Acquisition of sensitivity to tonality occurs implicitly: Such acquisition depends on exposure to Western music but not on formal music instruction.

**Recognizing Invariant Structure (“Music Conservation”).** Intelligent musical listening requires that we hear invariant structure underneath superficial transformations (e.g., hearing a melody played in different keys, at different speeds, or with different instruments as the same melody). Such recognition of underlying structure despite surface changes has been likened to Piagetian conservation tasks (Pflederer,
Children succeed on musical “conservation” tasks between the ages of 5 and 8 (and hence at the same age as they succeed on some Piagetian conservation tasks). Thus, children under age 5 are unable to identify a melody if its rhythm or harmonic accompaniments are altered, but by age 8 they have no difficulty with this task. The same findings hold for tasks in which children are asked to recognize meter despite a change in the duration of notes or to recognize rhythm despite a change in pitch (Pfleiderer, 1964; Serafine, 1980). But the analogy to conservation may be flawed. Children grasp conservation through logic, realizing that nothing has been added or taken away. There is no way to recognize invariance in music through logic. Instead, these studies are simply studies of perception and memory (Wolhwill, 1981).

**Perceiving Aesthetic Properties of Music**

**Expression.** More than any other art form, music has been described as the language of the emotions. According to philosopher Langer (1953), music mirrors the structure of emotional life: Music sounds the way moods feel. Music is structured in terms of tension and release, motion and rest, and fulfillment and change. These alterations mirror how our moods fluctuate. Whether or not they are musically trained, adults agree in general on the emotions expressed by music. We hear music in the major mode as expressing positive affect—in the minor mode as expressing negative affect; we hear dissonant chords as expressing agitation, excitement, or sorrow—consonant ones as expressing happiness and calm (Crowder, 1984; Hevner, 1936).

Does the experience of the major mode as happy, and the minor mode as sad depend on learning, or might this perception be universal and unlearned, a function of the acoustics of the major and minor modes? The ability to distinguish between major and minor modes is prerequisite to the ability to hear major as happier than minor, and Costa-Giomi (1996) showed that with brief training in learning to attend to mode, 5-year-olds can hear changes in mode.

Young children agree with adults in their interpretation of musical passages of happy or sad (Dolgin & Adelson, 1990; Kratus, 1993), though there is mixed evidence about how early the ability to recognize emotion in music emerges. Cunningham and Sterling (1988) found that children aged 5 (but not 4) agreed with adults about which pieces are happy, sad, or angry. Gentile, Pick, Flom, and Campos (1994) found that 3-year-olds agreed with adults on which pieces communicated happiness and which sadness, but only for five out of eight musical passages. Because these studies used actual segments of music, they do not allow us to determine which aspects of the music (e.g., mode, tempo, pitch, and volume) contributed to the emotion attribution.

Kastner and Crowder (1990) played 3- to 12-year-olds tunes in minor and major modes and asked them to point to the face that went with the tune (choosing among a happy, content, sad, and angry face). Even 3-year-olds matched positive faces to pieces played in the major mode (though performance improved with age). It is possible that children actually heard the major/minor distinction as a happy/sad one. But it is equally possible that children heard the major/minor distinction as a familiar/unfamiliar one, and gave positive choices when they heard something familiar. It is also possible that correct scores for the major mode were inflated by the selection of the “content” face which looked neutral (and children called it “plain”). A similar study used only a happy versus sad face, and found that 5-year-olds could not reliably match the minor melodies with the sad face and the major melodies with the happy face (Gerardi & Gerken, 1995). Thus, it may be that the perception of the minor mode as negative in affect and the major mode as positive emerges only with experience—perhaps the experience of hearing songs that pair sad lyrics or sad movies with the minor mode.

**Style.** A few studies have examined children’s ability to attend to the style of musical passages. Gardner (1973) asked children ages 6 to 19 to decide whether two passages from classical music came from the same piece and found that all children could succeed on this task though accuracy increased with age. When popular music was used along with classical music and children were asked to decide whether two passages came from the same piece of music, Castell (1982) found that 8-year-olds succeeded remarkably well, confirming Gardner’s findings. Both studies however showed that correct perceptual choices emerged earlier than the ability to verbalize what two passages deemed to be from the same piece had in common. Hargreaves (1982) documented the development of the ability to verbalize how two pieces are alike or different, and found that even 7- to 8-year-olds (the youngest he studied) were able to offer what he called “objective-analytic” responses describing the properties of the music.
Producing Music through Song: Major Milestones in Development

Children's first musical productions are vocal, and thus in what follows the focus is on the development of the ability to sing (both invented and standard songs). Singing is a complex task: Western rules of music dictate that songs consist of intervals sung an exact (rather than approximate) distance apart, melodies consist of diatonic notes and have a tonal center, and there is a consistent underlying metric organization. Children do not master these rules until the age of 6. Existing studies of the production of music through song are primarily descriptive rather than experimental.

Infant Song

Infants possess the rudimentary ability needed to make music: They vocalize and vary and imitate pitch. This early "singing" is much like scribbling and babbling.

Pitch Matching. Newborn cries have musical qualities and involve a wide range of pitches (Ostwald, 1973), but there is no reason to consider these cries as evidence of intentional music making. Kessen, Levine, and Wendrich (1979) provided evidence of intentional music making in infancy by showing that 3- to 6-month-olds could match isolated pitches sung to them on a pitch pipe. The ability to imitate sequences of two notes did not emerge prior to 1 year of age. See also Révész (1954) and Platt (1933) for earlier studies showing infants' ability to match pitches.

Babbled Songs. Even though 9- to 12-month-olds can imitate discrete pitches, when children this age sing they do so in continuous pitches on a single breath (sometimes called song babbling). This results in an undulating siren like sound in which pitches are blurred. This kind of sound is rarely heard in Western adult music. Babbled songs are not based on the diatonic system and have no clear rhythmic organization (McKernon, 1979; Moog, 1976; Moorhead & Pond, 1978).

Rhythm. In striking contrast to the evidence that children can imitate pitches, there is no evidence of intentional production of rhythm in the 1st year of life (Sloboda, 1985). To count as evidence of production of rhythm, it is not enough to see a child bang something over and over. One must look for subdivision of a beat so that there are two or more events within a regular superordinate pulse; omission of a beat with the picking up of the pulse at the correct time after a pause; imitation of a rhythmic pattern; and moving or beating in time to music (Sloboda, 1985).

Post-Infancy: Invented Songs

When it comes to language, children reach the level of the typical adult by age 5 or 6, with no explicit training; similarly, children sing at the level of the untrained adult by age 6. They have overcome three hurdles: (1) pitch has become discrete, (2) intervals have widened, and (3) their songs now have a metric and tonal organization.

Pitch Becomes Discrete. The undulating pitches of babbled song give way, at around 18 months, to an essential element of Western music—discrete pitches and discrete pitch intervals (Davidson, McKernon, & Gardner, 1981; McKernon, 1979; Werner, 1961). When children first begin to sing in discrete pitches, they do not yet use adult pitch categories—children do not yet sing in a diatonic scale (Dowling, 1988). In addition, pitches wander in and out of tune, interval sizes are not precise, and there is no tonal center (Dowling, 1984). At this age, children are not trying to imitate songs that they have heard; rather, they are inventing their own songs (Davidson et al., 1981; Moog, 1976).

Intervals Widen. The first intervals that children sing are very small, and development is characterized by a gradual expansion of interval size (Jersild &Bienstock, 1934; McKernon, 1979; Nettl, 1956a; Werner, 1961). McKernon found that major seconds were the most commonly produced intervals between 17 to 23 months. A third of the intervals sung at this age were of this type, and major seconds are among the most common intervals in songs across cultures (Nettl, 1956b). Between 1.5 to 2.5 years, the kinds of intervals increased and widened.

Children first expand their intervals and later fill them in a step-wise fashion (Davidson, 1985). Davidson refers to these early tonal structures as contour schemes—they are the stable intervals that the child possesses. These schemes are imposed on any song that a child acquires, reducing the range of a song's contour if necessary, and sometimes expanding the range to match the size of a new contour scheme just being constructed.
Melodies Gain Rhythmic and Tonal Organization. Rather than following a primarily rising or falling pattern, the contours of early songs undulate up and down (McKernon, 1979). Adult songs do this, too: Undulating contours are the most common types in adult songs across cultures (Nettl, 1956b). In this respect, as with the most common intervals produced, early songs resemble adult songs. But in their lack of either rhythmic or tonal organization, early songs are qualitatively different from adult songs (McKernon, 1979; Moorhead & Pond, 1978).

The melodic contours of children’s early songs are narrow despite the fact that children can vocalize across a wide range (Fox, 1990): And almost all contours range between middle C and the B seven notes above it. Early songs consist of atonal groups of pitches: They are chromatic rather than diatonic, based on any or all of the notes in an octave rather than on the notes of a particular scale, and thus they lack the tonal center heard in Western music (McKernon, 1979; Moorhead & Pond, 1978). The lack of melodic and rhythmic structure in children’s first invented songs makes these songs very different from the songs (written by adults) to which they are constantly exposed. By age 3, children are able to sing songs in a single key, though they do not do so reliably at first (McKernon, 1979).

Dowling (1984) described the invented songs his two daughters produced over a 5-year period, beginning in infancy. These children produced an average of 2.23 songs a week. The phrases of the songs had steady beats, but the beat did not always carry across phrases, consistent with findings by Moorhead and Pond (1978) and Moog (1976). Between ages 1 to 2, these two children produced songs with one repeated contour. By age 3, their songs had two to three different contours and often had a “coda,” a contour that occurs only at the end of the song. The use of a coda may well have been due to having heard nursery rhymes because this form is found more often in nursery rhymes than in other kinds of songs.

Post-Infancy: Conventional Songs

Imitated Songs. At around the age of 2, children attempt to sing the songs of their culture (Davidson, 1985; Davidson et al., 1981; McKernon, 1979). These early attempts to reproduce conventional songs sound very much like spontaneous songs in their lack of a metric and tonal organization. In both spontaneous songs and early renditions of standard songs, a narrow range of pitches and contours undulates in groups of two or three notes. The first property of a standard song imitated successfully is the lyrics—and these are simply imported into the child’s spontaneous musical repertoire without their accompanying tonal and rhythmic structure (McKernon, 1979; Moog, 1976). Next to be reproduced is a song’s rhythm. By 28 months, children studied by Davidson et al. (1981) could imitate the rhythmic structure of the alphabet song and fit the words appropriately into the rhythm. Last to develop is the ability to reproduce correct intervals and remain within a key. Adults pass through a similar sequence when learning a new song (Davidson et al., 1981).

By 29 months, children’s spontaneous tunes have diverged in sophistication from invented tunes (McKernon, 1979). By the age of 3 or 4, children’s standard songs have a clear underlying Western metric structure, even though their invented songs at this age lack this structure (McKernon, 1979). By age 5, spontaneous invented songs have declined and children become self-conscious and concerned with singing “correctly” according to the culture’s norms (Gardner & Wolf, 1983; Moog, 1976).

Children are able to reproduce rhythm before pitch. Five- to 7-year-olds were followed over 3 years as they learned the song, Row, Row, Row Your Boat (Davidson & Scripp, 1988). Accurate rhythm production requires that a person match the number of units, keep a steady underlying pulse, capture the surface grouping, and coordinate the underlying pulse with the surface notes. Accurate pitch production requires matching the initial pitch, the melodic contour, the interval boundary (highest and lowest notes), and the key. Most (85%) of the 5-year-olds got the rhythm right, but only about half got the pitch right. The ability to reproduce pitch developed rapidly so that by age 7 the gap between rhythm and pitch had narrowed considerably.

We can conclude that musically untrained children show quite sophisticated singing abilities. By the age of 2 or 3, they can reproduce the general contour of a melody even though they cannot reproduce pitches exactly. By age 4, they can maintain intervals but cannot sing in a stable key (because they shift keys at phrase boundaries; McKernon, 1979). They are sensitive to melodic contours very early but the acquisition of a stable tonal center is not present until age 5 or 6, when they can maintain a key. Thus, in both perception and production of music, tonality is a late-developing structure.
Intentional Expression in Singing. Children as young as age 4 can intentionally vary how they sing a song to convey emotion. Adachi and Trehub (1998) asked 4- to 12-year-olds to sing a familiar song (e.g., Twinkle, Twinkle, Little Star) once to make a listener happy and once to make her sad. Children at all ages primarily used devices that express emotion in both speech and music—they sang faster, louder, and at a higher pitch for happy and slower, softer, and lower for sad. Devices for emotion expression that are specific to music (e.g., mode or articulation) were infrequent at all ages studied. Not surprisingly, some age trends were seen: Adults are better able to interpret the happy versus sad expression in the songs of children ages 8 to 10 than in those of children ages 6 to 7 (Adachi & Trehub, 2000).

Post-Infancy: Invented Notations

By asking children to invent ways of notating music that they hear, we can learn whether children understand that music cannot be captured by words or pictures and requires its own system of representation. This understanding emerges at least as early as age 5. In the longitudinal study mentioned earlier in which 5- to 7-year-olds without musical training heard Row, Row, Row Your Boat, children were asked to write down “the song” so that another person could sing it back (Davidson & Scripp, 1988a). The most common kind of notation system at age 5 was one in which abstract symbols were used to represent the notes (e.g., increasingly long lines used to represent increasingly low notes). Forty-three percent of the 5-year-olds used some kind of invented abstract system. The second most common solution at age 5 (26%) was simply to draw a representational picture that captured nothing of the musical information (e.g., a picture of a boat in water). By age 7, 56% of the children still used an invented abstract notation, though half of these combined the abstract notations with words (and almost no children used representational pictures).

The task of notating music is one that these children have probably never encountered before. What is notable is that 5-year-olds did not all rely on pictures; many invented abstract symbols. By age 5, children have learned to write letters, and also know quite a bit about pictorial representation (as shown earlier in the discussion of drawing). When asked to represent music, they invent a symbol system that is independent of both language and pictorial representation. This finding shows that young children are not only inventive when it comes to symbolizing but also recognize that neither words nor pictures do an adequate job of representing music, and that music needs its own form of representational system.

Does Musical Skill Improve Linearly with Age?

In two areas, development in music does not steadily improve: (1) Absolute pitch capacity may decline with age and (2) young children demonstrate a “figural” understanding of music—a kind of understanding as sophisticated as that of adult musicians.

Absolute Pitch

Absolute pitch refers to the ability to recognize pitches when heard in isolation. This skill is typically assessed by asking people to name the pitch, but naming of the pitch is only one indication that the person recognizes the pitch. Other measures that have been used include the ability to sing back a pitch and the ability to say that this was the pitch they heard before. This incidence of absolute pitch is estimated at 1/1,500 to 1/10,000 (Bachem, 1955; Miyazaki, 1988; Profita & Bidder, 1988; Takeuchi & Hulse, 1993) though it is difficult to test for absolute pitch in nonmusicians because they have not learned about the names of musical notes. Among musicians the incidence is considerably higher, estimated to be between 5/100 and 50/100 (Chouard & Sposetti, 1991; Gregersen, Kowalsky, Kohn, & Marvin, 1999). Absolute pitch cannot be trained in adults. Many experiments have attempted to teach it (Crozier, 1997; Cuddy, 1968; Takeuchi & Hulse, 1993), but all that has been shown is that people can memorize a few tones with much practice. Genuine absolute pitch is not learnable.

However, there is evidence for the role of learning in early childhood because an early start to music training (before age 7) is associated with absolute pitch (Gregersen et al., 1999; Schlaug, Jäncke, Huang, & Steinmetz, 1995; Sergeant, 1969). But these data come from retrospective studies and it is possible that children with absolute pitch start music lessons earlier because their parents perceive them to be more musical. Not all musicians with absolute pitch began training early, and thus early training is not necessary for the development of absolute pitch. Moreover, only a minority of those who receive early training develop absolute pitch (Brown, Sachs, Cammuso, & Folstein, 2002).

Crozier (1997) and Takeuchi and Hulse (1993) reported greater trainability of absolute pitch in...
preschoolers than at older ages. There is also evidence that the incidence of absolute pitch declines with age. Sergeant and Roche (1973) found that absolute pitch is more common in 3- than 6-year-olds. Children were taught to sing three tunes over the course of six sessions over 3 weeks. One week after the last lesson, they were asked to sing the tunes. While the older children were able to sing back the song with the correct contour and precise intervals, it was the younger children who sang back the pitches most precisely. Saffran and Griepentrog (2001) showed that when only one kind of pitch cue (absolute or relative) is available, 8-month-olds discriminate tone patterns on the basis of absolute but not relative pitch. Adults responded in opposite fashion, succeeding only on the relative pitch task. Thus, the ability to store and reproduce pitches precisely may decline with age, giving way to the ability to grasp the overall gestalt of a tune. It is possible that absolute pitch becomes “unlearned” with age as children begin to focus on the distance between tones rather than the tones themselves. Without the ability to represent relative distance, we could not grasp musical structure (but see Plantinga & Trainor, 2004).

There is some debate about whether absolute pitch (as measured by pitch memory) really does decline with age. Trehub (2003) reports research in progress showing no age-related decline in remembering the absolute pitch level of familiar melodies. Trehub (in press) argues that both absolute and relative pitch processing exists from infancy onward, but with age, different triggers elicit one or the other mode of processing. She suggests that absolute pitch processing is universal if we measure it by testing whether individuals can remember the precise pitch level of music (Schellenberg & Trehub, 2003). Absolute pitch is considered to be rare, she argues, because we have insisted that to count as having absolute pitch one must be able to name individual notes heard in isolation. However, some researchers feel that we should reserve the term absolute pitch for the ability to classify pitch according to pitch class and not extend it to heightened pitch memory (Schlaug, 2003).

Schlaug et al. (1995) have shown that adult musicians with absolute pitch have a larger than normal left-sided asymmetry in the planum temporale. The planum temporale is involved in auditory processing and is related to language (its left-sided asymmetry is considered a marker of left-hemisphere language dominance in right-handers; Geschwind & Levitzky, 1968). Whether this atypical brain structure is inborn in those with perfect pitch, or develops as a function of intensive musical training begun at an early age, is not known. However, current longitudinal research in our lab in which children’s brains are imaged prior to and during music training may yield an answer to that question (Norton et al., 2004). If the atypical brain structure is inborn, research will need to determine whether some children with this brain structure lose absolute pitch and whether the maintenance of absolute pitch requires formal musical training and continuous exposure.

**Figural Understanding**

Children’s invented notations of music demonstrate that they hear music in an intuitive “figural” manner akin to how adult musicians are able to hear music. Bamberger (1991) asked a classroom of 8- and 9-year-olds to make drawings of a clapped rhythm so that someone else could clap back the rhythm. The rhythm had been invented by one of the children in the class and matched the rhythm of the familiar nursery tune, “Three, four, shut the door; five, six, pick up sticks; seven, eight, shut the gate.” Eight- and 9-year-olds invented two kinds of notations, which Bamberger refers to as figural and metric (or formal).

In the figural notation in Figure 20.12, claps 3-4-5 are shown to be alike. Clap 5 is like the two previous ones because all three form one rapidly clapped bounded figure. Figural drawings reveal that children are classifying claps in terms of gestures—the three small circles feel like they are all part of one gesture. In the formal notation in Figure 20.12, claps 5-6-7 are shown to be alike. Clap 5 is like 6 and 7, revealing that these children are classifying each clap in terms of duration from one clap to the next. To do this they must step back from the performance of clapping and compare claps.

Children who drew one kind of drawing could not understand how the other kind could be right. However,
both can be considered right because each captures a different aspect of the rhythm (Bamberger, 1991). Metric notations capture the relative durations of claps—just what standard music notation captures. Figural notations are intuitive phrasings of what the rhythm sounds like—and they capture what musicians refer to as phrasing. For example, a musical performance of the previously mentioned rhythm might involve making claps 3, 4, and 5 louder or softer than the first two to indicate that they form a unit. Children who invented metric notations had managed to transform the continuous flow of the physical act of clapping into static and discrete symbols. These symbols are qualitatively different from the figural ones that capture the bodily flow of making music. In a further study with a large number of 7- to 12-year-olds, Upitas (1987) found that even with formal music training, children favor figural notations (though once they were shown the metric form, children with training were more able to switch to this form than were musically untrained children).

Musicians are able to perceive music both metrically and figurally: They would not be able to impose phrasing on a score without figural understanding. Musical scores often do not contain phrase markings, leaving phrasing up to the musician’s interpretation. Thus, children’s early and untrained understanding of rhythms as figures is an understanding that is not discarded by experts but instead is maintained. Figural drawings are too often considered less developed than metric ones. Yet, figural drawings capture what is important for musical expression—playing musically and achieving musical coherence (Bamberger, 1982). Thus, the child’s earliest intuitive understanding of rhythm represents a way of knowing that remains important and ought to be retained even after more formal modes have been achieved. The challenge is for formal understanding to exist alongside figural understanding rather than have the formal replace the intuitive figural understanding.

CONCLUSIONS

A basic premise of developmental psychology holds that one can only study a developmental process of an implicitly or explicitly defined end state (Kaplan, 1967). Freud assumed the normal healthy personality; along with most cognitive-developmentalists, Piaget presupposed the full-blown logical scientific formal-operational thinker. But norms of mental health differ across groups and cultures, and the kind of scientific thought valued by Piaget has only emerged in recent centuries.

In this chapter, by focusing on two prevalent art forms, I have viewed cognitive development through a set of different and, I hope, freshly illuminating lenses. The arts address and sometimes answer issues that are less visible in other spheres. Among these issues are why humans persist in activities with nonobvious survival value, to what extent skills develop and even flower in the absence of formal training, and in which ways development may proceed in nonlinear and even regressive directions. In addition, it is particularly in the arts that links between early and adult end states can be seen: Both child and adult artist are experimenters. Artists deliberately violate rules they have mastered; children have not yet mastered the rules and are therefore willing to be playful.

Visual arts and music are distinctly separate domains—it makes little sense to conceive of artistic development as a single entity (just as there is no single course of scientific development that encompasses the biologist and the theoretical physicist). Issues of tonal accuracy or the privileged fifth in music have little direct analogy with the emergence of the tadpole or the horizon line in children’s drawings. And yet there may be certain intriguing parallels—children’s inventions of their own notations may involve some of the same processes as children’s attempts to master linear perspective (cf. Karmiloff-Smith, 1992). Even though the arts are universal in the way that science is not, I would not go so far as to claim that development perceived from a musical or visual artistic perspective provides the more important perspective. But I confidently assert that our understanding of development is enhanced if we can probe and synthesize findings from these various prized developmental end states.

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