RUNNING HEAD: ROLE OF TALENT IN THE VISUAL ARTS

The Rage to Master: The Decisive Role of Talent in the Visual Arts

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In this chapter, we argue for the decisive role of talent in achieving expertise in the visual arts. By talent, we refer to an innate ability or proclivity to learn in a particular domain. We argue that individual differences in innate ability exist, and that high levels of ability include a motivational component: a strong interest in a particular domain, along with a strong drive to master that domain. The same case for talent that we make here for the visual arts can also be made in many other domains. Specifically, we suggest, the case for talent can be made for any domain in which one finds childhood precocity or autistic and/or retarded savants.

It has been argued that hard work is all that there is to exceptional achievement in any domain. For instance, Howe (1990), arguing against the existence of innate individual differences in ability, suggested, "With sufficient energy and dedication on the parents' part, it is possible that it may not be all that difficult to produce a child prodigy" (p. 138). It is suggested that with enough practice and reward for achievement anyone can reach unusually high levels of performance in any domain. (For further elaboration of this argument, see Ericsson, 1988, 1996; Ericsson & Faivre, 1988; Ericsson, Krampe, & Tesch-Romer, 1993; Sloboda, Davidson, &; Howe, 1994).

Here are three widely cited pieces of evidence on which a strong environmental view of expertise might rest. The first comes from Roe's (1951, 1953a, 1953b) studies of eminent scientists. Roe found that what predicted outstanding achievement in science was not so much individual differences in intellectual abilities, but rather the capacity for endurance, concentration, and commitment to hard work. This has been taken to show that high achievement is more a function of tenacity than talent.
The second piece of evidence comes from Bloom's (1985) study of eminent people in science, arts, and athletics. Bloom found that none of his subjects achieved expertise without a supportive and encouraging environment, including a long and intensive period of training, first from loving and warm teachers, and then from demanding and rigorous master teachers.

The third piece of evidence comes from Ericsson's studies of adult experts in piano, violin, chess, bridge, and athletics (Ericsson et al., 1993). Ericsson demonstrated that levels of achievement reached in these domains correlate strongly with the sheer amount of deliberate practice in which these individuals have engaged. That is, those who spend more time working on difficult problems over and over in order to perfect them (deliberate practice) are the ones who reach the highest levels. He noted that in music, ballet, and chess, the higher the level of attained performance, the earlier the age of first exposure to the domain, and hence the earlier the onset of deliberate practice.

Each of these pieces of evidence, however, although clearly demonstrating the role of motivation, commitment, and hard work, fails to rule out the possibility that innate talent plays a necessary role in high achievement. First consider Roe's studies. The scientists studied were all high in intellectual ability to begin with. Thus, what these studies really show is that high ability by itself is not enough; they do not allow the reverse conclusion—that hard work by itself is enough to achieve eminence in science.

Second, consider Bloom's study. This study is often taken as strong evidence that eminent adults started out as perfectly ordinary children who had dedicated parents and teachers who motivated them to work long and hard. However, we believe this is a misreading. A careful look at the descriptions of these eminent individuals as children shows that at a very young age, prior to any regimen of training, signs of unusual ability were clearly evident. The musicians recalled
being quick to learn at the piano, and both their parents and teachers recognized them as special, as children worth devoting their efforts to. The sculptors recalled drawing constantly as children, usually realistically, and also enjoying working with their hands, building, hammering, and nailing. The mathematicians recalled a fascination with gears, valves, gauges, and dials, and were considered "brilliant" as children. Most of the interviewees said that they learned easily in their chosen domain, but did not learn as quickly in other areas in school. Thus, Bloom's work, like that of Roe, allows us only to conclude that hard work is necessary for the acquisition of expertise, but not that it is sufficient.

Finally, consider our third piece of evidence, the studies by Ericsson and his colleagues. The problem here is that hard work and innate ability have not been unconfounded. Those children who have the most ability may also be those who are most interested in a particular activity, who begin to work at that activity at an early age, and who work the hardest at it. One is likely to want to work hard at something when one is able to advance quickly with relatively little effort, but not when every step is a painful struggle. Thus, Ericsson's research, like that of Roe and of Bloom, demonstrates the importance of hard work but in no way allows us to rule out the role of innate ability.

Psychologists would never assert that retardation is due to too little training or not enough drill. No one disputes the biological basis of retardation (with the exception of that due to extremely impoverished environment); and yet some do assert that high ability, the flip side of retardation, is entirely due to hard work. But if biological retardation exists, why not biological acceleration?

In this chapter, we use evidence from the domain of the visual arts to make the case for the role of talent in the achievement of expertise. We review what is known about the drawings
of children who draw in advance of their age level, as well as what is known about other characteristics of these children. To avoid begging the question, we refer to children who draw in advance of their age as precocious rather than gifted or talented. We make no assumptions about whether the cause of this precocity is biological or environmental.

At the conclusion of the chapter, we evaluate the evidence that drawing precocity has innate, biological component. We argue that although it is impossible to isolate ability from practice (because high-ability children always practice), there is converging evidence to demonstrate that practice without ability is not enough to explain expertise. First, high achievers in the visual arts have high ability before they begin to work at drawing extensively. Second, ordinary children cannot be motivated or even forced to work at drawing to the extent that a precocious child willingly does so. Third, precocious drawers display different kinds of drawing abilities than do ordinary children who simply work hard at drawing. We also argue that there are other signs besides drawing precocity that these children are atypical from birth: They are often non-right-handed, they display a variety of visual-spatial strengths, and also tend to have linguistic deficits. This combination of factors suggests a brain-based component of drawing talent that can account for drawing precocity both in autistic and retarded savants as well as in nonpathological children.

The strong role of innate talent, however, does not allow us to rule out the importance of practice and hard work. Through practice, learning occurs. Even the most prodigious show development of their skills, and this development is a function of intense work. We argue that precocious drawers, as well as children who are highly precocious in any domain, differ from the ordinary child in these four respects:

1. They learn more rapidly in the domain.
2. They are intrinsically motivated to acquire skill in the domain (because of the ease with which learning occurs). We call this having a rage to master.

3. They make discoveries in the domain without much explicit adult scaffolding. A great deal of the work is done through self-teaching, which, as pointed out by Charness et al. (1996) and Ericsson (1996), can be a form of deliberate practice.

4. They not only make discoveries on their own, but often do things in the domain that ordinary hard workers never do—inventing new solutions, thinking, seeing, or hearing in a qualitatively different way.

Does Drawing Precocity Exist?

There have been far fewer reports of reputed drawing prodigies than of prodigies in math, music, and chess. Studies searching for drawing prodigies in populations of schoolchildren have concluded that drawing talent in very young children was far rarer than talent in other domains (Goodenough, 1926; Lark-Horowitz, Lewis, & Luca, 1973). Although it is possible that drawing ability is rarer than ability in other domains, cultural factors could also account for the discrepancy. Drawing ability is far less valued in our culture than is mathematical ability; children who show ability in music are immediately given music lessons; children who show ability in chess join chess clubs and participate in competitions much as do young athletes. Children are not routinely screened for drawing ability as they are for academic ability; nor are they typically signed up for formal lessons as they are in music. When the culture supports a particular domain, talent is more readily recognized and then nurtured; but also, such a culture makes clear what the skills are that need to be mastered for excellence to be achieved (Csikszentmihalyi & Robinson, 1986).
It is likely that many children who draw ahead of their age go unnoticed and thus unnurtured by their parents and their schools. Moreover, we now have numerous reports of children who appear to be prodigies in drawing (Cane, 1951; Drake & Winner, in press; Gardner, 1989; Goldsmith, 1992; Goldsmith & Feldman, 1989; Golomb, 1992, 1995; Golomb & Hass, 1995; Milbrath, 1987, 1995, 1998; Paine, 1981; Selfe, 1977, 1983, 1985, 1995; Wilson & Wilson, 1977; Winner, 1996; Winner & Martino, 1993; Zhensun & Low, 1991; Zimmermann, 1992). Thus, early high achievement in drawing is clearly possible. Whether such achievement is as common as high achievement in other domains seems less important than the fact that it does occur.

**Typical Characteristics of Precocious Drawings**

Our knowledge of early high achievement in drawing comes from two sources. One source is the childhood drawings of famous artists (Beck, 1928; Gordon, 1987; Paine, 1987; Pariser, 1987, 1991; Richardson, 1991; Vasari 1957). The problem with this kind of evidence is that it is so sparse, and we have almost no drawings by artists preserved from before the age of 9. Thus we know nothing about the first signs of drawing in those who went on to become artists. A more informative source is children who have been identified as precocious in drawing by their parents or teachers. These children do not necessarily become artists as adults, but their drawings are at least several years in advance of those of their peers. Both sources of evidence point consistently to the following set of characteristics as typical of precocious drawings.

**Recognizable and Differentiated Shapes.** The earliest sign of precocity in drawing is the ability to draw recognizable shapes 1 to 2 years in advance of the normal age timetable of 3 to 4 years of age. Whereas children typically scribble until about 3 to 4, precocious children draw clearly recognizable shapes by the age of 2. Figure 1 shows a typical 2-year-old's scribble. Figure
2 contrasts a precocious and age typical attempt at drawing apples. Both drawings were made by 2-year olds. The age-typical child drew a slash for each apple (Figure 2a). For him, a slash stood for anything. The precocious child drew each apple's shape, along with the stem (Figure 2b). For him, the representation had to capture the apple's contour in order to represent an apple. Figure 3 shows a fish by another precocious 2-year-old, which also captures the appropriate contour.

*Fluid Contour.* Whereas 3-and 4-year-olds typically represent humans by tadpoles, with a circle representing an undifferentiated head and trunk (Figure 4), some precocious children draw the human figure with head and trunk differentiated by age 2 (Golomb, 1995). Preschoolers typically draw additively, juxtaposing geometric shapes (e.g., to make a human, they make a circle for a head, an oval for the body, and straight lines for arms and legs). In contrast, precocious children draw the whole object with one fluid contour line (Winner & Martino, 1993; Figure 5).

Precocious drawers draw recognizable, realistic images quickly and with ease. They do not labor over and erase their lines. Picasso was reported to begin drawings from noncanonical places (e.g., drawing a dog starting with the ear), with no decrement in speed or confidence (Richardson, 1991).

*Details.* Precocious children do not depict a generic object, but include a rich amount of detail. For example, one child added gas tanks, axles, grills, bumpers, headlights, and brake boxes to his vehicles (Golomb, 1992). Another child drew dinosaurs with scientific accuracy, using paleontology books to acquire the needed information (Milbrath, 1995). The inclusion of detail is one way in which the drawings of precocious children achieve realism.

*Techniques to Represent Depth.* Precocious drawers achieve the illusion of realism not only by drawing differentiated shapes and details, but also by depicting the third dimension.
They use all of the known Western techniques to show depth: foreshortening, occlusion, size diminution, modeling to show volume, and even the most difficult technique of all, linear perspective. In a comparison of ordinary and precocious drawers, Milbrath (1995) showed that the precocious sample used all of these techniques years earlier than did the normal sample. For instance, foreshortening was used in 50% of the drawings by Milbrath's precocious sample by age 7 and 8; comparable levels in the normal sample were reached only by ages 13 and 14, 6 years later.

Linear perspective is used by precocious drawers sometimes almost as soon as they begin to draw (e.g., the case of Eitan reported by Golomb, 1992, 1995). But the perspective systems used are at first primitive ones, and they are applied locally to separate objects on the page, rather than in a unified fashion to the entire scene (Milbrath, 1987, 1995, 1998). Nonetheless, the invention of perspectival drawing systems by very young children is astounding to see. Linear perspective is a convention, and it is not an intuitively obvious one (Gombrich, 1960). Typically children in the West do not begin to draw in perspective until middle childhood, and only those who have explicit instruction ever attain true geometric perspective (Willats, 1977).

Perhaps the most extreme example of the untutored invention or discovery of linear perspective is the case of Eitan reported by Golomb (1992, 1995). Eitan's parents report that Eitan consistently resisted instruction and insisted on working on his own. Eitan's first drawings at age 2 were flat and displayed the object from a frontal view (e.g., as seen in Figure 3). However, he was not satisfied with showing only canonical views, because by 2;2 he began to juxtapose different views of the same object, resulting in a feeling of solidity and depth. Figure 6 shows his first attempt to show depth. Here Eitan has drawn some kind of a vehicle (perhaps a
tractor or a bicycle) but he did not just draw a flat frontal view of the wheels. Instead he gave them a look of three-dimensionality by juxtaposing a side and top view of the wheels.

Eitan discovered (or invented) three perspective systems:

1. He juxtaposed different faces of an object along the horizontal or vertical axis (horizontal and vertical oblique perspective; Figure 7).
2. He drew the sides of an object with lines diverging out from the frontal plane (divergent perspective).
3. He drew the sides of an object with oblique parallel lines (Figure 8). By 4, this kind of perspective, called isometric, was his preferred strategy, and was used quite systematically by age 6 (see Figure 9), but he did use converging lines to represent depth at 3;8.

The perspective systems that Eitan used followed a logical progression, identical to the progression followed by ordinary children. However, there are three important differences: the early age at which he began, the rapid speed with which he passed through different perspectival "stages," and the fact that he was entirely self-taught.

**Orientation.** Precocious drawers vary the orientation of figures, in contrast to the canonical orientation used by ordinary children. For instance, a comparison of drawings by ordinary and precocious children showed that human figures were drawn in three-quarters view only 15% of the time by ordinary children between 11 and 14 years. In contrast, by age 6 precocious drawers used this orientation in half of their figure drawings (Milbrath, 1995). These three-quarter views appeared abruptly between 6 and 7 years. Note that a three-quarters view is a distortion, just as is foreshortening, size diminution, occlusion, and so on. Precocious drawers are willing to distort the size and shape of objects in order to show them as they appear to the eye.
All of the characteristics just described make precocious drawings look exceptionally realistic. The ability to draw realistically at a precocious age also marks the childhoods of those who have gone on to become recognized artists. Gordon (1987) studied the childhood works of 31 Israeli artists and found that all stood out for their ability to draw realistically. Sloane and Sosniak (1985) interviewed 20 sculptors and found that most recalled drawing realistically at a very early age. Many other famous artists' early drawings have been singled out for their advanced realism: for example, Millais (Paine, 1981), Landseer (Goldsmith & Feldman, 1989), Seargent (Cox, 1992), and Klee, Picasso, and Lautrec (Pariser, 1987, 1991). Picasso recalled one of his first drawings in this way: "I was perhaps six.... In my father's house there was a statue of Hercules with his club in the corridor, and I drew Hercules. But it wasn't a child's drawing. It was a real drawing, representing Hercules with his club" (Richardson, 1991, p. 29).

Although almost all Western children identified as accelerated in drawing have drawn realistically, Golomb (1991) discovered two artists whose childhood drawings stood out for their aesthetic sense but not for their realism (see also Golomb & Hass, 1995). The childhood works of these two artists showed an advanced sense of composition and color. Admittedly, it is more difficult to demonstrate that a drawing is advanced aesthetically than to show that it is advanced in realism, as the criteria for measuring aesthetics are far less clear than those for measuring realism. Nonetheless, the drawings of these children stood out on fairly clearly measurable dimensions. They were filled with decorative properties; colors were used in a highly expressive manner, and colors and shapes were endlessly and inventively varied. Thus, although an ability to draw realistically may be the most typical and striking characteristic of Western children who draw precociously, exceptional nonrepresentational skill with design, form, and color also occurs
in children who draw precociously. Similar cases have been described by Hurwitz (1983), Kerchensteiner (1905), and Lark-Horowitz, Lewis, and Luca (1973).

Realism as an early indicator of precocity in drawing may well be culturally determined. In the West, at least from the Renaissance until the 20th century, artists have striven to capture the illusion of space, volume, and depth (Gombrich, 1960). Although precocious drawers probably begin to draw realistically long before they have looked closely at examples of Western realistic art, they have certainly been exposed to illusionist images on billboards, magazines, picture books, and so on. What about children not exposed to such examples?

We have one well-known example, a Chinese painting prodigy who, because she grew up in China, probably saw far fewer examples of Western illusionist images than do Western children (Goldsmith, 1992; Goldsmith & Feldman, 1989; Zhensun & Low, 1991). Yani was spared traditional Chinese drawing instruction because her artist father felt such instruction killed the artistic imagination. However, Yam spent many hours a day in her father's art studio painting alongside her father. Although her father insists that he did not teach her, we really do not know whether Yani received any kind of instruction from her father. We do know that she painted all the time, and she painted way in advance of her years.

Yani's paintings looked nothing like those by Western gifted children. Instead, hers were painted in the allusionistic, impressionistic style of traditional Chinese brush painting (Figure 10). What we think she shares with Western children who draw precociously is the ability to master the pictorial conventions of one's culture. In the West this means mastering the convention of perspective and realism. In China this means mastering the convention of capturing the spirit of objects, not their exact likeness. Thus, like Eitan, Yani was able at an abnormally early age to make pictures that looked remarkably like the adult art of her culture.
The Compulsion to Draw

So far we have discussed the characteristics of the drawings produced by children who draw at a precocious level. We now turn to a pervasive characteristic of the children themselves: their compulsion to draw.

The children who draw in the manner we have described draw constantly and compulsively. Peter, a precocious drawer, began to draw at 10 months, in contrast to the typical age of about 2 (Winner, 1996). Once he discovered that he could make marks on paper, Peter wanted to draw all the time. Soon he was waking up in the mornings and bellowing for paper and markers before getting out of bed. He drew before breakfast, during breakfast, while getting ready for school, while being driven to school, and as soon as he returned home from school. His drawings were of the kind typically produced by precocious drawers—advanced in realism. Peter was particularly skilled at drawing fluid Klee-like figures in a wide variety of moving positions (Figures 5, 11, 12, 13). When friends came over to play, he would bore them by making them pose for him, or by insisting that they draw with him. Peter and Eitan showed the same kind of fascination with drawing reported by Sloane and Sosruak (1985) of sculptors as young children.

The compulsion to draw found in precocious drawers has its parallels in many other domains. That is, any time a child is precocious in a particular activity, that child is also highly interested in and drawn to work at that activity. One can find children who spend hours every day finding and solving math problems; not surprisingly, these children also are precocious at math, and able to think about mathematical concepts far beyond the reach of their peers. The same kinds of children have been noted in music, chess, and reading. Winner (1996) has studied a number of these children, and the parallels are striking. For example, take the case of Jacob, a child who heard heavy metal music on the electric guitar at age 4 and begged his parents for 2
years to let him play the electric guitar. His parents did not consider this a childlike kind of music, and thus they resisted Jacob's pleadings for 2 years. However, confronted with the intensity of Jacob's interest, they finally bought him a guitar and found him a teacher. At his first lesson, scheduled for 30-minutes, Jacob refused to leave. Whereas most children are relieved that a lesson is over, Jacob did not want it to end. After his second lesson, his teacher was certain that Jacob was a prodigy. He could play back just about anything by ear, he could master complex music seemingly without effort, and he could improvise in a musical manner. Once while on an outing with his father, Jacob passed a group of street musicians. He asked to try their electric guitar and astonished bystanders, who were heard joking that he must be a reincarnation of Jimi Hendrix.

Jacob played his guitar from the moment he got home from school until he had to go to bed. His parents never had to ask him to practice, for there was no difference for Jacob between playing for fun and practicing. He set himself challenges and worked on them for hours. Instead of the usual story of prodding the child to practice, his parents had to pry him away from his instrument to eat, sleep, and go to school.

The same phenomenon of precocity linked with drive can be seen in the description of Josh Waitzkin, the child chess player in the book and movie, Searching for Bobby Fischer (Waitzkin, 1984). At age 6, Josh watched several games of chess with great interest, and then began to play chess himself. His coach immediately recognized that he had exceptional ability because the very first time he played he used the sophisticated strategy of combining pieces to launch an attack. He was also able to calculate 15 to 20 moves ahead. Like Jacob, Josh showed a rage to master. He could not be stopped from watching and playing chess for hours each day. His
father said that between the ages of 6 and 8, he studied chess as intensively as a college student studies for a comprehensive exam.

Now one could argue that all of these examples of children who work so hard and achieve so much simply demonstrate the role of practice in achieving expertise. These children work harder than do typical children and thus naturally they achieve higher levels. However, this kind of argument assumes that the hard work comes first, the high achievement later and it fails on two grounds. To begin with, even the very first productions of precocious children are advanced. The earliest drawings of Eitan and Peter were not normal. They drew recognizable forms by 2; within a few months Eitan was using linear perspective, and by 3 Peter was drawing very complex, fluid figures in motion. The same kinds of claims can be made for precocious children in other domains. As just mentioned, the first time 6-year-old Josh Waitzkin played chess, after having observed the game just a few times he combed pieces to launch an attack, certainly not a strategy that children normally alight on initially. The second time that Jacob came to his guitar lesson, his teacher decided he was a prodigy. These signs of ability came before any instruction, and before any time for deliberate practice.

Of course, all of these children went on to learn immense amounts about their domain, and this learning was acquired primarily independently. They certainly engage in what might be called deliberate practice. Where they differed from ordinary children was in the independence with which they worked (they needed little or no tutoring) and the ease with which they discovered the rules of their domain. This difference is one that is attributable to innate talent in the domain.

The second problem with the argument that the hard work causes the high achievement is that it does not explain what motivates these children to work so hard. One cannot even cajole or
force a normal child to draw or play music or chess all day, and the children we are talking about insisted on spending their time in this way. Indeed, they often had to be dragged away from their preferred activities in order to eat, sleep, go to school, and be sociable. The interest, drive, and desire to work on something must be part and parcel of the talent. Of course, as we have already indicated, and as Charness et al. (1996) and Ericsson (1996) have argued, the daily hours spent working on something lead to improvement that would not occur without the daily work. However, the desire to work so hard at something comes from within, not without, and occurs almost always when there is an ability to achieve at high levels with relative ease.

Because precocity and drive tend to co-occur, it is difficult to determine the relative contribution of each. However the fact that precocity and drive so often co-occur is not simply a natural confound that befuddles our research efforts. This co-occurrence also tells us something of critical importance, namely, that drive (or what we call the rage to master) is an ineluctable part of talent.

Occasionally one finds examples of hard work without what we would call innate talent. We refer to these children as drudges, in contrast to those we would call gifted. In the domain of drawing there exists a published record of drawings produced by a child who was obsessed with drawing, who drew constantly, but who never made much progress. This child, Charles, described by Hildreth (1941), provides us with a vivid example of hard work, perhaps one might say deliberate practice, without much innate ability. Charles produced over 2,000 drawings of trains from the time he was 2 until he was 11, most of them drawn between the ages of 7 and 9. Charles clearly drew 2 to 3 years ahead of his age, but as Figures 14, 15, and 16 show, although he made some progress, his drawings never reached a level anywhere near to those of Eitan or
Peter. True, his drawings became more complex, more realistic, and more controlled. But after age 4, his drawings showed little development, and even at age 11 his drawings were fairly schematic and showed neither Eitan's mastery of perspective nor Peter's ability to capture contours in motion.

Another kind of example of the effects of hard work without talent can be found in any urban preschool and elementary school in contemporary China. Chinese children are given explicit instructions in drawing from the age of 3, when they enter kindergarten; and from the age of 6 they have daily practice in copying calligraphy (Gardner, 1989; Winner, 1989). These children are taught in a meticulous, step-by-step manner how to produce a wide variety of graphic schemas found in traditional Chinese painting: bamboo, goldfish, shrimp, chickens, roosters, and so on. They are taught precisely which lines to make, and the direction and order in which to make them. They learn by copying, but eventually they are able to go beyond copying and draw from life. Whereas ordinary Western children are given virtually no instruction in drawing, and are simply given materials with which to explore and experiment, ordinary Chinese children are given very detailed instruction in drawing as a skill. Thus, the drawings of ordinary Chinese children appear controlled, neat, skilled, and adultlike, whereas those of ordinary Western children appear free, messy, unskilled, and childlike (see Figure 17). It is undoubtedly the instructional regimen imposed on the Chinese child that accounts for the difference.

One can see the same phenomenon in the domain of music. Ordinary Japanese children trained in the Suzuki method of violin begin to play the violin at a very young age and practice

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1 The first author is indebted to Rudolf Arnheim and Claire Golomb for bringing Hildreth’s study to her attention as an example of what can be achieved with work but no exceptional talent.
every day. These children play in a disciplined, controlled, musical manner at a very young age, and appear on the surface as if they are all musical prodigies.

_Precocious Drawers are not Just Ahead, They are Different_

Although Chinese drawers and Suzuki violinists perform at a level that makes them look highly skilled, they are really very different from the kinds of children we described earlier-those who not only choose to draw, play music, or solve math problems, but who insist on doing so, and all the time. Ordinary Chinese children become very proficient at drawing but would never be confused with Yani. Nor would Suzuki violinists ever be confused with a young Yehudi Menuhin or the Japanese violin prodigy, Midori. Yani far surpasses the average Chinese child in skill and inventiveness, as does Midori the average Suzuki-trained violinist.

Precocious drawers seem to be able to do things with lines on paper that are simply never mastered by ordinary children who work hard at drawing. Here are a few ways in which they differ. First, as already mentioned, they are self-taught. For example, they invent techniques such as perspective and foreshortening on their own, whereas ordinary children require instruction to arrive at these achievements. Second, they show a confidence in their line, and an ability to draw a complex contour with one fluid line. Ordinary children never arrive at this. Witness Charles' trains (Hildreth, 1941). Third, they can begin a drawing from any part of the object drawn, and draw objects from noncanonical orientations. This ability suggests a strong visual imagery ability (see the following for evidence of this). Strong visual imagery is also suggested by the way in which these children often draw something vividly that they have seen months, even years ago (Selfe, 1995; Winner, 1996). Fourth, these children are highly inventive, and endlessly vary their compositions, forms, and sometimes colors. Note how Eitan varied his perspective systems, and how Peter varied the positions of his figures in motion.
Precocious drawers are sometimes able to draw at a level considerably higher than the typical adult. Take for instance, Arkin Rai, a 5-year old from Singapore. At age two and a half, Arkin’s drew a tadpole figure, shown in Figure 18, that is very similar to the tadpole by a typical 3-year-old shown in Figure 4. Thus, he was already advanced but only by about a half a year. However, only two and a half years later, he drew dinosaur scenes, shown in Figure 19, that are far ahead of how any typical adult can draw—replete with examples of occlusion, foreshortening, and figures in motion. Arkin also shows the ability – characteristic of gifted children – to hyper focus. For example, at a restaurant he drew a complex narrative sequence on the printed paper placement (Figure 20). He was able to tune out what was on the placement and not allow it to interfere with his drawing. The narrative sequences he draws are the products of his imagination. It would be difficult to conceive of how a fertile imagination can be developed through practice! In any case, the notion that any child could make Arkin’s progress in two and a half years simply by drawing as often as this child did is absurd.

Children with precocious drawing ability are not just advanced: they also are different. We recently demonstrated that children who draw realistically at an above average level differ in their perceptual skills and drawing strategies from typical children. We assessed children in their level of observational drawing skill and demonstrated that drawing skill (level of realism achieved) was strongly associated with the use of a local perceptual processing strategy (focusing on the parts rather than the whole) (Drake, Redash, Coleman, Haimson, & Winner, 2010). For example, we administered a version of the Block Design Task once in traditional format, and once with the blocks segmented in space from one another, making it easier to copy the designs with actual blocks. Typical children are helped by presentation of the task in segmented form, as the segmentation reveals each part (or segment) of the design to be
reproduced with blocks. Individuals with autism spectrum disorder (ASD) are less helped by presentation of the task in segmented form, showing that they are able to mentally analyze the designs into their parts (Caron, Mottron, Berthiaume, & Dawson, 2006; Shah & Frith, 1993). We demonstrated that non-autistic children precocious in drawing realism are also less helped than typical children by segmented presentation of the task. These children were also able to detect shapes hidden in complex figures more rapidly than children who drew at a typical level. Thus, like those with ASD, the children with precocious drawing skills were able to focus on the details and avoid the context. In this study we also assessed whether children began their drawings with small details or whether the first sketched in the overall outline of what they were going to draw. We found that the greater the drawing skill, the more children began first with the details rather than the global outline.

Taken together, these findings show that children who are precocious in drawing are not only advanced but also approach drawing differently from typical children, using a local processing strategy. While we do not have evidence that this processing style is innate, it seems highly unlikely that one could develop this style through practice. Rather it seems more plausible to assume that this kind of processing style is an unlearned tendency that contributes to realistic drawing skill.

The ability to invent and discover in a domain has its parallel in all other domains in which one finds precocious children. Josh Waitzkin discovered the strategy of combing pieces to launch an attack in chess. Musical children start improvising, transposing, and composing on their own; they often have perfect pitch, and can hear errors that others cannot. Bloom's pianists were noted by their teachers to learn with great ease. Mathematical children invent novel ways of
solving problems, and ask mathematical questions that ordinary children who work hard at their math lessons, and do well just do not ask.

In short, precocious children are not mere drudges. They are not ordinary children who know how to work hard. Not only can one not make ordinary children spend hours a day at drawing or chess or math, but even if one could, as in China or Japan, these children do not achieve with instruction what precocious children achieve on their own.

Potential Biological Markers of Drawing Talent

We have thus far argued for the existence of children who draw at a precocious level, and who are driven to work hard at drawing. We have argued that the drive to work at drawing, and the interest in drawing, is inextricably connected to the precocity. Moreover, the precocity is seen from the outset, and thus cannot be a consequence of hard work.

We now turn to what we argue are biological markers of talent in the visual arts. The case that we make is that children who show precocity in drawing have a particular profile. These children have a higher than average likelihood of being non-right-handed, and of having visual-spatial strengths along with linguistic deficits. The profile cut by these children can be seen in extreme and exaggerated form in the profile of abilities and disabilities seen in drawing savants. This profile of abilities and disabilities is consistent with the existence of a biological component to drawing expertise.

Higher Than Average Incidence of Non-Right-Handedness

A disproportionate number of adult artists and children who draw precociously are non-right-handed (Mebert & Michel, 1980; Peterson, 1979; Rosenblatt & Winner, 1988; Smith, Meyers, & Kline, 1989). For instance, in one study it was shown that 21% of art students were left-handed, compared to only 7% of nonart majors at the same university; 48% of the art
students were non-right-handed (i.e., either left-handed or ambidextrous), compared to 22% of the nonart majors (Mebert & Michel, 1980). No environmental explanation can make sense of this finding: Artists do not need to use both hands when drawing, and even very young precocious drawers show this tendency, often drawing interchangeably with both hands (Winner, 1996).

Non-right-handedness is a marker albeit an imperfect one, of anomalous brain dominance. It is estimated that about 70% of the population has standard dominance—a strong left-hemisphere dominance for language and hand (yielding right-handedness) and a strong right-hemisphere dominance for other functions such as visual spatial and musical processing (Geschwind & Galaburda, 1985). Those remaining 30% with anomalous dominance have more symmetrical brains (with language and visual-spatial functions represented somewhat on both sides of the brain).

**Visual-Spatial Strengths**

Anomalous dominance has been argued to result in a tendency toward inborn ability in areas for which the right hemisphere is important (e.g., visual-spatial, musical, or mathematical areas; Geschwind & Galaburda, 1985), and children who draw precociously have been shown to possess other visual-spatial strengths besides the ability to render. There are anecdotal reports of unusually vivid and early visual memories in these children (Winner, 1996). There is also experimental evidence for advanced visual-spatial strengths in children whose drawings are unusually skilled. Such children excel in visual memory tasks of various sorts (Hermelin & O’Connor, 1986, Rosenblatt & Winner, 1988; Winner & Casey, 1992; Winner, Casey, DaSilva, & Hayes, 1991). For example, they are better able to recognize nonrepresentational shapes that they have seen before (Hermelin & O’Connor, 1986) and to recall shapes, colors, compositions, and
forms in pictures (Rosenblatt & Winner, 1988). They also show superior ability to recognize what is represented in incomplete drawings (O'Connor & Hermelin, 1983), suggesting that they have a rich lexicon of mental images. And they excel mentally rotating image in three-dimensional space, as do children who are labeled as gifted in math as well as adults who choose math as a college major (Winner & Casey, 1992). Thus, precocious drawers show the kinds of right-hemisphere skills that would be predicted by anomalous dominance. It is perhaps because of strong imaging abilities that these children are able to begin drawings from noncanonical places, and can draw from memory images they have seen long ago.

Linguistic Deficits. Anomalous dominance has also been argued to lead to deficits in areas for which the left hemisphere is important, resulting in language-related problems such as dyslexia (Geschwind & Galaburda, 1985). This hypothesis can be tested either by assessing heightened right-hemisphere abilities in dyslexic children, or by assessing frequencies of dyslexia in children who draw precociously. Both ways of testing the hypothesis yield a clear and consistent picture of an association between visual-spatial ability and language-related learning disorders.

Many studies have shown that on IQ tests, dyslexic children score higher on subtests assessing right-hemisphere spatial skills than on those assessing left-hemisphere sequential skills (Gordon, 1983; Gordon & Harness, 1977; Naidoo, 1972; Rugel, 1974). For instance, they score higher on constructing patterns or puzzles than on recalling sequences of numbers. These findings fit with anecdotal observations of visual-spatial talent in dyslexics (Galaburda & Kemper, 1979).

The same association shows up when either adults or children who draw at high levels are examined for verbal problems. Artists score poorly on tests of verbal fluency (Hassler, 1990),
they report more reading problems as children than do other college students (Winner et al., 1991), and they make more spelling errors than do other students (Winner et al., 1991). Moreover, the kinds of spelling errors they make are just those associated with poor reading skills—nonphonetically based errors that do not preserve letter-sound relationships (Frith, 1980; Phillips, 1987). Nonphonetically based errors are ones in which wrong letters are included, correct ones are omitted, or letters are reversed (e.g., physician for physicians); in contrast, phonetically based errors are ones that when sounded out, sound right (e.g., "physician"). This tendency to make nonphonetically based errors was found by Winner et al. (1991) even when SAT performance was partialed out. This suggests that artistically inclined individuals have problems specific to reading and spelling that are independent of the kinds of abilities measured by the SAT.

Thus individuals who show high achievement in the visual arts have a tendency toward non-right-handedness and also have heightened right-hemisphere skills and lowered left-hemisphere skills. The confluence of non-right-handedness, spatial skills, and linguistic problems has been dubbed a "pathology of superiority" by Geschwind and Galaburda (1985, p. 445). Geschwind and Galaburda argued that such pathologies of superiority were due to the hormonal environment of the developing fetal brain. In particular, either excess testosterone, or heightened sensitivity to testosterone, was argued to slow development of an area of the brain's left posterior hemisphere. Slowing of the left hemisphere was argued to lead to compensatory development of the right hemisphere, and thus to result in the emergence of talents associated with the right hemisphere such as music, drawing, and mathematics. This theory remains controversial (see Bryden, McManus, & Bulman-Fleming, 1994; Schader, 1994). Nonetheless, there is as yet no other theory that can explain the established fact that ability in drawing is
associated both with non-right-handedness and dyslexia. This fact lends support to the claim that children who draw precociously are different from the start.

*Drawing Savants.* The final piece of evidence that we present in favor of a biological component to drawing expertise is the existence of drawing savants. Savants are people who show prodigious ability in one area, but severe retardation in all other areas. Although such individuals are rare, generalizations about them can be drawn. They are typically found in one of four domains: music (almost always piano), mental calculation, calendar calculation, and visual arts (almost always realistic drawing). There have been numerous attempts to explain the savant syndrome. Environmental explanations appeal to practice and reinforcement (Ericsson & Faivre, 1988). Psychodynamic explanations appeal to a compensatory search for a communication channel when language is lacking. However, we argue here that a biological explanation of these individuals is the only feasible one because of the rapidity with which they acquire the domain, their lack of need for scaffolding, and their drive to master. Moreover, savants can be seen as particularly extreme examples of the pathology of superiority. Savants have a highly developed skill (usually one subserved by the right hemisphere), and are deficient in everything else.² The severity of their pathology limits them to a restricted set of domains, and also limits what they can do in these domains.

The most famous drawing savant is Nadia, an autistic child who drew at least from the age of 3;6 on (Selfe, 1977, 1983, 1985, 1995). Her drawings preserved from this age are drawn in perspective, with foreshortening, occlusion, and correct proportion. Her drawings are more

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² Savantism in calculation, a left-hemisphere skill, can also be explained by Geschwind and Galaburda's (1985) theory. They argued that in addition to compensatory right-hemisphere development, regions next to the left posterior areas may also undergo compensatory development.
advanced than those of any nonpathologically gifted child that we know of (Figure 21), but other autistic children have also been shown to draw at an exceptional level (Park, 1978; Sacks, 1985, 1995; Wiltshire, 1987). These savants resemble precocious drawers. They draw early and a lot, and they also stand out as different from ordinary children in the same ways as do precocious drawers. They discover perspective and foreshortening and other depth techniques on their own, they can begin a drawing from any part of the object, they draw with astounding confidence and fluidity of line, and they can draw from memory objects and pictures they have seen months or years ago.

We recently reported on the drawing ability in an autistic child J.G. who showed clear savant-level drawing skills (Drake & Winner, in press). J.G. is able to draw in a highly realistic manner using dramatic foreshortening (e.g., see Figure 22), has a strong visual memory (he can recount in vivid detail what he has seen) and shows a strong local processing bias – as shown by the near equivalence of his performance on the segmented vs. unsegmented Block Design Task (described above) as well as on the Embedded Figures Test. This local processing bias also manifested itself in the process by which he drew from observation: like the savant, E.C. described by Mottron and Belleville (1993), J.G. drew using a strategy of local progression. We asked him to draw a corkscrew. He did not sketch in the overall shape but rather created the corkscrew part-by-part, beginning at the top and working his way down.

Heightened drawing ability exists in only a small subset of autistic children (Charman & Baron-Cohen, 1993), and we do not know whether anything else differentiates this subset of autistic children from those who draw at their mental level (Selje, 1995). Nonetheless, the existence of extraordinary drawing ability in the presence of retardation and autism, and in the absence of any explicit instruction, calls for a biological, brain-based explanation. If the high
drawing ability of savants were simply due to the fact they draw all the time (which they do), then one would expect savants in any domain. All that would be required is compulsive practice. The fact that savants are found only in certain domains suggests that practice cannot be the explanation. Moreover, the intense drive to draw (or play music, or calculate mentally) seen in savants is what leads to the compulsive practice. We have to explain the intense drive for mastery in a domain that we see in savants just as we see in normal children. This rage to master is part of the talent; it does not explain the talent.

Conclusion

We have tied to disentangle hard work (sometimes referred to as deliberate practice but we prefer the term “rage to master”) from talent in order to argue that talent is innate, and therefore is prior to hard work. Talent is associated with a rage to master in the talent domain. A rage to master means hard work. And hard work in a domain leads to ever-increasing levels of achievement. It is useful to think in terms of four logically possible combinations of hard work and talent.

Most children have neither exceptional talent in drawing nor do they spend much time at drawing. These children never draw particularly well. Some children have no exceptional talent but they work hard at drawing. The Chinese schoolchildren and Hildreth's train drawer are examples of such children. These children are able to draw at a level considerably beyond their age. Some children have talent but by early adolescence they disengage from their domain of talent, often because of competing demands by school and family (Csikszentmihalyi, Rathunde, & Whalen, 1993). Finally, there are those with both talent and a drive to work that continues undiminished into adulthood. These are the Picassos, the Yanis; in music, these are the Mozarts and the Menuhins; in science, these are Roe's eminent scientists.
What kind of further evidence would one need to conclude definitively that talent plays a decisive role in expertise in drawing or in other areas? Ideally, one would need to take a large sample of young and untutored children, selected at random, and submit them to identical levels of deliberate practice. Three conditions would have to obtain to demonstrate that hard work begun at an early age is all that is necessary to explain the Picassos and Mozarts of the world. First, all of the children must eventually achieve the same levels of expertise with the same levels of work. Second, all children would have to learn in the same way, mastering what is given to them rather than deviating and inventing their own techniques. Third, with sufficient work and time, the levels reached must be as high as those reached by individuals we consider truly exceptional. Only then could we rule out talent as a factor in high accomplishment. We, for one, would place our bets on quite different outcomes: highly differential levels achieved despite the same amount of work; difficulty getting most of the children to work as hard as some of the children; those that work willingly also inventing techniques on their own; and no levels achieved concomitant to those achieved by Yani, Picasso, Mozart, or Menuhin.

While the kind of study outlined above has not been done, and probably never will be done, there are now two studies that provide strong evidence that deliberate practice is not sufficient to account for extraordinary levels of performance.

A study from the domain of music demonstrates that deliberate practice is not sufficient. Meinz and Hambrick (2010) compared the relative importance of deliberate practice and working memory capacity in piano sight-reading skills in novice to expert piano players. Deliberate practice explained almost half of the variance in piano sight-reading skills. However, working memory capacity explained variance above and beyond deliberate practice. These results demonstrate that deliberate practice is not sufficient and that poor working memory
capacity may limit achieving expertise. One cannot argue that working memory is simply a product of deliberate practice since working memory capacity was shown to contribute independently to the level of sight-reading reached.

The best systematic evidence disentangling nature from nurture comes from studies of chess masters (Gobert & Campitelli, 2007; Howard, 2009). These researchers were able to disentangle amount of deliberate practice from level of chess achieved, and they reported wide individual variation in the number of hours needed to reach grandmaster level. If some people reach grandmaster level with fewer hours of practice than others, we cannot account for the level they reached only by amount of deliberate practice. There must be another factor that allows some people to progress more rapidly with less practice, and that factor is most plausibly an innate proclivity to learn rapidly in the domain in question. These researchers also found players who put in huge amounts of chess time (from childhood) yet never attained master level. Thus, sheer hard work is simply not sufficient to make someone a chess master. What is true of chess is bound to be true of all kinds of great achievers, whether in the arts, the sciences or athletics, though comparable studies have not yet been conducted.
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Figure Captions

1. Typical scribble by 2-year-old.

2. Apples drawn by typical 2-year-old (a) and by a precocious 2-year-old (b). From Winner 1996.

3. Fish by Eitan at age 2;2. From Golomb (1992).

4. Typical tadpole human by 3-year-old.

5. Drawing of a girl by Peter, a precocious drawer, at age 4;6, showing a fluid contour line.

6. Tractor or bicycle by Eilan, age 2;2, showing a juxtaposed side and top view of the wheels, making them look three-dimensional. From Golomb (1992).

7. Cement truck by Eitan, age 2;7, showing the side view of the truck, the top view of the hood, and a frontal view of grill and bumper. From Golomb (1992).

8. Truck by Eltan, age 3;7, showing isometric perspective, in which the third dimension is represented by parallel oblique lines. From Golomb (1992).


10. Painting by Yani, age 5, entitled “Pull Harder"

11. Drawing of girl in bathing suit by Peter, age 3;7.

12. Drawing of ballerina by Peter, age 4;6.

13. Drawing of the Clintons by Peter, age 6;1.

14. Examples of the fruits of drawing practice without much innate talent: All drawings by Charles are from Hildreth (1941). (a) Drawing of train by Charles, age 2, showing tracks and differentiation between engine and passenger cars. (b) Drawing of train by Charles, age 3, showing noncanonical front view, and showing tracks smaller behind the train, but
with no converging lines. (c) Drawing of train by Charles, age 4, showing three-dimensional space by vertical positioning (the farther trains are placed higher up). (d) Drawing of train by Charles, age 5, showing differentiated passenger and freight trains.

15. Further drawings by Charles, ages 6 to 9. (a) Drawing of train by Charles, age 6, showing trains receding in distance and diminishing in size. (b) Drawing of train by Charles, age 7, which appears no more advanced than drawing at age 6. (c) Drawing of train by Charles, age 8, in canonical side view. (d) Drawing of train by Charles, age 9, showing technique of diminishing size to suggest depth.

16. Drawings by Charles at ages 10 and 11: (a) Drawing of train by Charles, age 10, in canonical side view, (b) Drawing of train by Charles, age 11, showing increase in detail, still drawn inn canonical side view.

17. Brush and ink painting by a typical (nonprecocious) Chinese 6.year~old, showing high skill level as a consequence of regular, formulaic, drawing instruction.


20. Complex scene drawn on a place mat by Arkin Rai at age 5, and with part of image enlarged. Reprinted by permission of Dinesh Rai.


22. Drawing of a jaguar by J.G., at age 9, showing dramatic foreshortening. From Drake & Winner (in press).
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