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Crucial Differences

ARTHUR R. JENSEN

The main difference between genius and stupidity, I am told, is that genius has limits. A simple answer, and undoubtedly true. But my assignment here is to reflect on the much more complex difference between intellectual *giftedness* and *genius*, using the latter term in its original sense, as socially recognized, outstandingly creative achievement. In this think-piece (which is just that, rather than a comprehensive review of the literature), I will focus on factors, many intriguing in and of themselves, that are characteristic of genius. My primary thesis is that the emergence of genius is best described using a multiplicative model.

I will argue that exceptional achievement is a multiplicative function of a number of different traits, each of which is normally distributed, but which in combination are so synergistic as to skew the resulting distribution of achievement. An extremely extended upper tail is thus produced, and it is within this tail that genius can be found. An interesting two-part question then arises: how many different traits are involved in producing extraordinary achievement, and what are they? The musings that follow provide some conjectures that can be drawn on to answer this critical question.

As a subject for scientific study, the topic of genius, although immensely fascinating, is about as far from ideal as any phenomenon one can find. The literature on real genius can claim little besides biographical anecdotes and speculation, with this chapter contributing only more of the same. Whether the study of genius will ever evolve from a literary art form into a systematic science is itself highly speculative. The most promising efforts in this direction are those by Simonton (1988) and Eysenck (1995), with Eysenck's monograph leaving little of potential scientific value that can be added to the subject at present, pending new empirical evidence.

Intelligence

Earlier I stated that genius has limits. But its upper limit, at least in some fields, seems to be astronomically higher than its lower limit. Moreover, the upper limit of genius cannot be described as characterized by precocity, high intelligence, knowledge and problem-solving skills being learned with speed and ease, outstanding academic achievement, honors and awards, or even intellectual productivity. Although such attributes are commonly found at all levels of genius, they are not discriminating in the realm of genius.

My point is perhaps most clearly illustrated by the contrast between two famous mathematicians who became closely associated with one another as "teacher" and "student." The reason for the quotation marks here will soon be obvious, because the teacher later claimed that he learned more from the student than the student had learned from him. G. H. Hardy was England's leading mathematician, a professor at Cambridge University, a Fellow of the Royal Society, and the recipient of an honorary degree from Harvard. Remarkably precocious in early childhood, especially in mathematics, he became an exceptionally brilliant student, winning one scholarship after another. He was acknowledged the star graduate in mathematics at Cambridge, where he remained to become a professor of mathematics. He also became a world-class mathematician. His longtime friend C. P. Snow relates that Hardy, at the peak of his career, ranked himself fifth among the most important mathematicians of his day, and it should be pointed out that Hardy's colleagues regarded him as an overly modest man (Snow, 1967). If the Study of Mathematically Precocious Youth (SMPY) had been in existence when Hardy was a schoolboy, he would have been a most prized and promising student in the program.

One day Hardy received a strange-looking letter from Madras, India. It was full of mathematical formulations written in a quite unconventional—one might even say bizarre—form. The writer seemed almost mathematically illiterate by Cambridge standards. It was signed "Srinivasa Ramanujan." At first glance, Hardy thought it might even be some kind of fraud. Puzzling over this letter with its abstruse formulations, he surmised it was written either by some trickster or by someone sincere but poorly educated in mathematics. Hardy sought the opinion of his most highly esteemed colleague, J. E. Littlewood, the other famous mathematician at Cambridge. After the two of them had spent several hours studying the strange letter, they finally realized, with excitement and absolute certainty, that they had "discovered" a major mathematical genius. The weird-looking formulas, it turned out, revealed profound mathematical insights of a kind that are never created by ordinarily gifted mathematicians. Hardy regarded this "discovery" as the single most important event in his life. Here was the prospect of fulfilling what, until then, had been for him only an improbable dream: of ever knowing in person a mathematician possibly of Gauss's caliber.

A colleague in Hardy's department then traveled to India and persuaded Ramanujan to go to Cambridge, with all his expenses and a salary paid by the university. When the youth arrived from India, it was evident that, by ordinary standards, his educational background was meager and his almost entirely self-taught knowledge of math was full of gaps. He had not been at all successful in school, from which he had flunked out twice, and was never graduated. To say, however, that he was *obsessed* by mathematics is an understatement. As a boy in Madras, he was too poor to buy paper on which to work out his math problems. He did his prodigious mathematical work on a slate, copying his final results with red ink on old, discarded newspapers.

While in high school, he thought he had made a stunning mathematical discovery, but he later learned, to his great dismay, that his discovery had already been made 150 years earlier by the great mathematician Euler. Ramanujan felt extraordinary shame for having "discovered" something that was not original, never considering that only a real genius could have created or even recreated that discovery.

At Cambridge, Ramanujan was not required to take courses or exams. That would have been almost an insult and a sure waste of time. He learned some essential things from Hardy, but what excited Hardy the most had nothing to do with Ramanujan's great facility in learning the most advanced concepts and technical skills of mathematical analysis. Hardy himself had that kind of facility. What so impressed him was Ramanujan's uncanny mathematical intuition and capacity for inventing incredibly original and profound theorems. That, of course, is what real mathematical genius is all about. Facility in solving textbook problems and in passing difficult tests is utterly trivial when discussing genius. Although working out the proof of a theorem, unlike discovering a theorem, may take immense technical skill and assiduous effort, it is not itself a hallmark of genius. Indeed, Ramanujan seldom bothered to prove his own theorems; proof was a technical feat that could be left to lesser geniuses. Moreover, in some cases, because of his spotty mathematical education, he probably would have been unable to produce a formal proof even if he had wanted to. But a great many important theorems were generated in his obsessively active brain. Often he seemed to be in another world. One might say that the difference between Ramanujan creating a theorem and a professional mathematician solving a complex problem with standard techniques of analysis is like the difference between St. Francis in ecstasy and a sleepy vicar reciting the morning order of prayer.

After his experience with Ramanujan, Hardy told Snow that if the word *genius* meant anything, he (Hardy) was not really a genius at all (Snow, 1967, p. 27). Hardy had his own hundred-point rating scale of his estimates of the "natural ability" of eminent mathematicians. Though regarding himself at the time as one of the world's five best pure mathematicians, he gave himself a rating of only 25. The greatest mathematician of that period, David Hilbert, was rated 80. But Hardy rated Ramanujan 100, the same rating as he gave Carl Frederick Gauss, who is generally considered the greatest mathematical genius the world has known. On the importance of their total contributions to mathematics, however, Hardy rated himself 35, Ramanujan 85, and Gauss 100. By this reckoning Hardy was seemingly an overachiever and Ramanujan an underachiever. Yet one must keep in mind that Ramanujan died at age thirty, Hardy at seventy, and Gauss at seventy-eight.

Of course, all geniuses are by definition extreme overachievers, in the statistical sense. Nothing else that we could have known about them besides the monumental contributions we ascribe to their genius would have predicted such extraordinary achievement. In discussing Ramanujan's work, the Polish mathematician Mark Kac was forced to make a distinction between the "ordinary genius" and the "magician." He wrote:

> An ordinary genius is a fellow that you and I would be just as good as, if we were only many times better. There is no mystery as to how his mind works. Once we understand what he has done, we feel certain that we, too, could have done it. It is different with the magicians. They are, to use mathematical jargon, in the orthogonal complement of where we are and the working of their minds is for all intents and purposes incomprehensible. Even after we understand what they have done, the process by which they have done it is completely dark. (Quoted in Kanigel, 1991, p. 281; Kanigel's splendid biography of Ramanujan is highly recommended)

To come back to earth and the point of my meandering, genius requires giftedness (consisting essentially of *g*, often along with some special aptitude or talent, such as mathematical, spatial, musical, or artistic talent). But obviously there are other antecedents (to the magic of Ramanujan's "thinking processes") that are elusive to us. Nonetheless, we do know of at least two key attributes, beyond ability, that appear to function as catalysts for the creation of that special class of behavioral products specifically indicative of genius. They are productivity and creativity.

Creativity

Although we can recognize creative acts and even quantify them after a fashion (MacKinnon, 1962), our understanding of them in any explanatory sense is practically nil. Yet one prominent hypothesis concerning creativity (by which I mean the bringing into being of something that has not previously existed) seems to me not only unpromising, but extremely implausible and probably wrong. It is also inherently unfalsifiable and hence fails Popper's criterion for a useful scientific theory. I doubt that it will survive a truly critical examination. Because ruling out one explanation does further our understanding of creativity, I will focus on this theory.

I am referring here to what has been termed the *chance configuration theory* of creativity (well explicated by Simonton, 1988, ch. 1). Essentially, it amounts to expecting that a computer that perpetually generates strictly random sequences of all the letters of the alphabet, punctuation signs, and spaces will eventually produce *Hamlet* or some other work of creative genius. The theory insists that *blind chance* acting in the processes of memory searches for elements with which to form random combinations and permutations, from which finally there emerges some product or solution that the world considers original or creative. It is also essential that, although this generating process is operating entirely by blind chance, the random permutations produced thereby are subjected to a critical rejection/selection screening, with selective retention of the more promising products. This theory seems implausible, partly because of the sheer numerical explosion of the possible combinations and permutations when there are more than just a few elements. For example, the letters in the word *permutation* have 11! = 39,916,800 possible permutations. To discover the "right" one by randomly permuting the letters at a continuous rate of one permutation per second could take anywhere from one second (if one were extremely lucky) up to one year, three thirty-day months, and seven days (if one were equally unlucky). Even then, these calculations assume that the random generating mechanism never repeated a particular permutation; otherwise it would take much longer.

The combinatorial and permutational explosion resulting from an increase in the number of elements to be mentally manipulated and the exponentially increased processing time are not, however, the worst problems for this theory. The far greater problem is that, just as "nature abhors a vacuum," the human mind abhors randomness. I recall a lecture by the statistician Helen M. Walker in which she described a variety of experiments showing that intelligent people, no matter how sophisticated they are about statistics or how well they understand the meaning of randomness, and while putting forth their best conscious efforts, are simply *incapable* of selecting, combining, or permuting numbers, letters, words, or anything else in a truly random fashion. For example, when subjects are asked to generate a series of random numbers, or repeatedly to make a random selection of *N* items from among a much larger number of different objects spread out on a table, or take a random walk, it turns out no one can do it. This has been verified by statistical tests of randomness applied to their performance. People even have difficulty simply reading aloud from a table of random numbers without involuntarily and nonrandomly inserting other numbers. (Examples of this phenomenon are given in Kendall, 1948.)

Thus, randomness (or blind chance, to use the favored term in chance configuration theory) seems an unlikely explanation of creative thinking. This theory seems to have originated from what may be deemed an inappropriate analogy, namely the theory of biological evolution creating new living forms. According to the latter theory, a great variety of genetic effects is produced by *random* mutations and the screening out of all variations except those best adapted to the environment—that is, natural selection. But a genetic mutation, produced perhaps by a radioactive particle hitting a single molecule in the DNA at random and altering its genetic code, is an unfitting analogy for the necessarily integrated action of the myriad neurons involved in the mental manipulation of ideas.

The Creative Process

The implausibility of randomness, however, in no way implies that creative thinking does not involve a great deal of "trial-and-error" mental manipulation, though it is not at all random. The products that emerge are then critically sifted in light of the creator's aim. The individuals in whom this mental-manipulation process turns out to be truly creative most often are those who are relatively rich in each of three sources of variance in creativity: (1) *ideational fluency*, or the capacity to tap a flow of relevant ideas, themes, or images, and to play with them, also known as "brainstorming"; (2) what Eysenck (1995) has termed the individuals' *relevance horizon*; that is, the range or variety of elements, ideas, and associations that seem relevant to the problem (creativity involves a wide relevance horizon); and (3) *suspension of critical judgment*.

Creative persons are intellectually high risk takers. They are not afraid of zany ideas and can hold the inhibitions of self-criticism temporarily in abeyance. Both Darwin and Freud mentioned their gullibility and receptiveness to highly speculative ideas and believed that these traits were probably characteristic of creative thinkers in general. Darwin occasionally performed what he called "fool's experiments," trying out improbable ideas that most people would have instantly dismissed as foolish. Francis Crick once told me that Linus Pauling's scientific ideas turned out to be wrong about 80 percent of the time, but the other 20 percent finally proved to be so important that it would be a mistake to ignore any of his hunches.

I once asked another Nobel Prize winner, William Shockley, whose creativity resulted in about a hundred patented inventions in electronics, what he considered the main factors involved in his success. He said there were two: (1) he had an ability to generate, with respect to any given problem, a good many hypotheses, with little initial constraint by previous knowledge as to their plausibility or feasibility; and (2) he worked much harder than most people would at trying to figure out how a zany idea might be shaped into something technically feasible. Some of the ideas that eventually proved most fruitful, he said, were even a physical impossibility in their initial conception. For that very reason, most knowledgeable people would have dismissed such unrealistic ideas immediately, before searching their imaginations for transformations that might make them feasible.

Some creative geniuses, at least in the arts, seem to work in the opposite direction from that described by Shockley. That is, they begin by producing something fairly conventional, or even trite, and then set about to impose novel distortions, reshaping it in ways deemed creative. I recall a demonstration of this by Leonard Bernstein, in which he compared the early drafts of Beethoven's Fifth Symphony with the final version we know today. The first draft was a remarkably routine-sounding piece, scarcely suggesting the familiar qualities of Beethoven's genius. It was more on a par with the works composed by his mediocre contemporaries, now long forgotten. But then two processes took hold: (1) a lot of "doctoring," which introduced what for that time were surprising twists and turns in the harmonies and rhythms, along with an ascetic purification, and (2) a drastic pruning and simplification of the orchestral score to rid it completely of all the "unessential" notes in the harmonic texture, all the "elegant variations" of rhythm, and any suggestion of the kind of filigree ornamentation that was so common in the works of his contemporaries. This resulted in a starkly powerful, taut, and uniquely inevitable-sounding masterpiece, which, people now say, only Beethoven could have written. But when Beethoven's symphonies were first performed, they sounded so shockingly deviant from the prevailing aesthetic standards that leading critics declared him ripe for a madhouse.

One can see a similar process of artistic distortion in a fascinating motion picture using time-lapse photography of Picasso at work (*The Picasso Mystery*). He usually began by sketching something quite ordinary—for example, a completely realistic horse. Then he would begin distorting the figure this way and that, repeatedly painting over what he had just painted and imposing further, often fantastic, distortions. In one instance, this process resulted in such an utterly hopeless mess that Picasso finally tossed the canvas aside, with a remark to the effect of "Now I see how it should go." Then, taking a clean canvas, he worked quickly, with bold, deft strokes of his paintbrush, and there suddenly took shape the strangely distorted figure Picasso apparently had been striving for. Thus he achieved the startling aesthetic impact typical of Picasso's art.

It is exactly this kind of artistic distortion of perception that is never seen in the productions of the most extremely gifted idiot savants, whose drawings often are incredibly photographic, yet are never considered works of artistic genius. The greatest artists probably have a comparable gift for realistic drawing, but their genius leads them well beyond such photographic perception.

Other examples of distortion are found in the recorded performances of the greatest conductors and instrumentalists, the re-creative geniuses, such as Toscanini and Furtwängler, Paderewski and Kreisler. Such artists are not primarily distinguished from routine practitioners by their technical skill or virtuosity (though these are indeed impressive), but by the subtle distortions, within fairly narrow limits, of rhythm, pitch, phrasing, and the like, that they impose, consciously or unconsciously, on the works they perform. Differences between the greatest performers are easily recognizable by these "signatures." But others' attempts to imitate these idiosyncratic distortions are never subtle enough or consistent enough to escape detection as inauthentic; in fact, they usually amount to caricatures.

Psychosis

What is the wellspring of the basic elements of creativity listed above—ideational fluency, a wide relevance horizon, the suspension of inhibiting self-criticism, and the novel distortion of ordinary perception and thought? All of these features, when taken to an extreme degree, are characteristic of psychosis. The mental and emotional disorganization of clinical psychosis is, however, generally too disabling to permit genuinely creative or productive work, especially in the uncompensated individual. Eysenck, however, has identified a trait, or dimension of personality, termed *psychoticism*, which can be assessed by means of the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1991). Trait psychoticism, it must be emphasized, does not imply the psychiatric diagnosis of psychosis, but only the predisposition or potential for the development of psychosis (Eysenck & Eysenck, 1976). In many creative geniuses, this potential for actual psychosis is usually buffered and held in check by certain other traits, such as a high degree of ego strength. Trait psychoticism is a constellation of characteristics that persons may show to varying degrees; such persons may be aggressive, cold, egocentric, impersonal, impulsive, antisocial, unempathic, tough-minded, and creative. This is not a charming picture of genius, perhaps, but a reading of the biographies of some of the world's most famous geniuses attests to its veracity.

By and large, geniuses are quite an odd lot by ordinary standards. Their spouses, children, and close friends are usually not generous in their personal recollections, aside from marveling at the accomplishments for which the person is acclaimed a genius. Often the personal eccentricities remain long hidden from the public. Beethoven's first biographer, for example, is known to have destroyed some of Beethoven's letters and conversation books, presumably because they revealed a pettiness and meanness of character that seemed utterly inconsistent with the sublime nobility of Beethoven's music. Richard Wagner's horrendous character is legendary. He displayed virtually all of the aforementioned features of trait psychoticism to a high degree and, to make matters worse, was also neurotic.

Trait psychoticism is hypothesized as a key condition in Eysenck's (1995) theory of creativity. Various theorists have also mentioned other characteristics, but some of these, such as self-confidence, independence, originality, and nonconformity, to name a few, might well stem from trait psychoticism. (See Jackson & Rushton, 1987, for reviews of the personality origins of productivity and creativity.)

Productivity

A startling corollary of the multiplicative model of exceptional achievement is best stated in the form of a general law. This is Price's Law, which says that if K persons have made a total of N countable contributions in a particular field, then $N/2$ of the contributions will be attributable to $\sqrt{K}$ (Price, 1963). Hence, as the total number of workers (K) in a discipline increases, the ratio $\sqrt{K}/K$ shrinks, increasing the elitism of the major contributors. This law, like any other, only holds true within certain limits. But within fairly homogeneous disciplines, Price's Law seems to hold up quite well for indices of productivity—for example, in math, the empirical sciences, musical composition, and the frequency of performance of musical works. Moreover, there is a high rankorder relationship between sheer productivity and various indices of the importance of a contributor's work, such as the frequency and half-life of scientific citations, and the frequency of performance and staying power of musical compositions in the concert repertoire. (Consider such contrasting famous contemporaries as Mozart and Salieri; Beethoven and Hummel; and Wagner and Meyerbeer.)

If productivity and importance could be suitably scaled, however, I would imagine that the correlation between them would show a scatter-diagram of the "twisted pear" variety (Fisher, 1959). That is, high productivity and triviality are more frequently associated than low productivity and high importance. As a rule, the greatest creative geniuses in every field are astoundingly prolific, although, without exception, they have also produced their share of trivia. (Consider Beethoven's *King Stephen* Overture and Wagner's "United States Centennial March," to say nothing of his ten published volumes of largely trivial prose writings—all incredible contrasts to these composers' greatest works.) But such seemingly unnecessary trivia from such geniuses is probably the inevitable effluvia of the mental energy without which their greatest works would not have come into being. On the other hand, high productivity is probably much more common than great importance, and high productivity per se is no guarantee of the importance of what is produced. The "twisted pear" relationship suggests that high productivity is a necessary but not sufficient condition for making contributions of importance in any field. The importance factor, however, depends on creativity—certainly an elusive attribute.

What might be the basis of individual differences in productivity? The word *motivation* immediately comes to mind, but it explains little and also seems too intentional and self-willed to fill the bill. When one reads about famous creative geniuses one finds that, although they may occasionally have to force themselves to work, they cannot *will* themselves to be *obsessed* by the subject of their work. Their obsessive-compulsive mental activity in a particular sphere is virtually beyond conscious control. I can recall three amusing examples of this, and they all involve dinner parties. Isaac Newton went down to the cellar to fetch some wine for his guests and, while filling a flagon, wrote a mathematical equation with his finger on the dust of the wine keg. After quite a long time had passed, his guests began to worry that he might have had an accident, and they went down to the cellar. There was Newton, engrossed in his mathematical formulas, having completely forgotten that he was hosting a dinner party.

My second example involves Richard Wagner. Wagner, while his guests assembled for dinner, suddenly took leave of them and dashed upstairs. Alarmed that something was wrong, his wife rushed to his room. Wagner exclaimed, "I'm doing it!"—their agreed signal that she was not to disturb him under any circumstances because some new musical idea was flooding his brain and would have to work itself out before he could be sociable again. He had a phenomenal memory for musical ideas that spontaneously surfaced, and could postpone writing them down until it was convenient, a tedious task he referred to not as composing but as merely "copying" the music in his mind's ear.

Then there is the story of Arturo Toscanini hosting a dinner party at which he was inexplicably morose and taciturn, just as he had been all that day and the day before. Suddenly he got up from the dinner table and hurried to his study; he returned after several minutes beaming joyfully and holding up the score of Brahms's First Symphony (which he was rehearsing that week for the NBC Symphony broadcast the following Sunday). Pointing to a passage in the first movement that had never pleased him in past performances, he exclaimed that it had suddenly dawned on him precisely what Brahms had intended at this troublesome point. In this passage, which never sounds "clean" when played exactly as written, Toscanini slightly altered the score to clarify the orchestral texture. He always insisted that his alterations were only the composer's true intention. But few would complain about his "delusions"; as Puccini once remarked, "Toscanini doesn't play my music as I wrote it, but as I dreamed it."

Mental Energy

Productivity implies actual production or objective achievement. For the psychological basis of intellectual productivity in the broadest sense, we need a construct that could be labeled *mental energy*. This term should not be confused with Spearman's *g* (for general intelligence). Spearman's theory of psychometric *g* as "mental energy" is a failed hypothesis and has been supplanted by better explanations of *g* based on the concept of neural efficiency (Jensen, 1993). The energy construct I have in mind refers to something quite different from cognitive ability. It is more akin to cortical arousal or activation, as if by a stimulant drug, but in this case an endogenous stimulant. Precisely what it consists of is unknown, but it might well involve brain and body chemistry.

One clue was suggested by Havelock Ellis (1904) in *A Study of British Genius*. Ellis noted a much higher than average rate of gout in the eminent subjects of his study; gout is associated with high levels of uric acid in the blood. So later investigators began looking for behavioral correlates of serum urate level (SUL), and there are now dozens of studies on this topic (reviewed in Jensen & Sinha, 1993). They show that SUL is only slightly correlated with IQ, but is more highly correlated with achievement and productivity. For instance, among high school students there is a relation between scholastic achievement and SUL, even controlling for IQ (Kasl, Brooks, & Rodgers, 1970). The "over-achievers" had higher SUL ratings, on average. Another study found a correlation of +.37 between SUL ratings and the publication rates of university professors (Mueller & French, 1974).

Why should there be such a relationship? The most plausible explanation seems to be that the molecular structure of uric acid is nearly the same as that of caffeine, and therefore it acts as a brain stimulant. Its more or less constant presence in the brain, although affecting measured ability only slightly, considerably heightens cortical arousal and increases mental activity. There are probably a number of other endogenous stimulants and reinforcers of productive behavior (such as the endorphins) whose synergistic effects are the basis of what is here called mental energy. I suggest that this energy, combined with very high *g* or an exceptional talent, results in high intellectual or artistic productivity. Include trait psychoticism with its creative component in this synergistic mixture and you have the essential makings of genius.

To summarize:

Genius = High Ability × High Productivity × High Creativity.

The theoretical underpinnings of these three ingredients are:

—Ability = *g* = efficiency of information processing

—Productivity = endogenous cortical stimulation

—Creativity = trait psychoticism

Other Personality Correlates

There are undoubtedly other personality correlates of genius, although some of them may only reflect the more fundamental variables in the formula given above. The biographies of many geniuses indicate that, from an early age, they are characterized by great sensitivity to their experiences (especially those of a cognitive nature), the development of unusually strong and long-term interests (often manifested as unusual or idiosyncratic hobbies or projects), curiosity and exploratory behavior, a strong desire to excel in their own pursuits, theoretical and aesthetic values, and a high degree of self-discipline in acquiring necessary skills (MacKinnon, 1962).

The development of expert-level knowledge and skill is essential for any important achievement (Rabinowitz & Glaser, 1985). A high level of expertise involves the automatization of a host of special skills and cognitive routines. Automatization comes about only as a result of an immense amount of practice (Jensen, 1990; Walberg, 1988). Most people can scarcely imagine (and are probably incapable of) the extraordinary amount of practice that is required for genius-quality performance, even for such a prodigious genius as Mozart.

In their *self*-assigned tasks, geniuses are not only persistent but also remarkably able learners. Ramanujan, for example, disliked school and played truant to work on math problems beyond the level of anything he was offered at school. Wagner frequently played truant so he could devote his whole day to studying the orchestral scores of Beethoven. Francis Galton, with an estimated childhood IQ of around 200 and an acknowledged genius in adulthood, absolutely hated the frustrations of school and pleaded with his parents to let him quit. Similar examples are legion in the accounts of geniuses.

In reading about geniuses, I consistently find one other important factor that must be added to the composite I have described so far. It is a factor related to the direction of personal ambition and the persistence of effort. This factor channels and focuses the individual's mental energy; it might be described best as personal ideals or values. These may be artistic, aesthetic, scientific, theoretical, philosophical, religious, political, social, economic, or moral values, or something idiosyncratic. In persons of genius, especially, this "value factor" seems absolutely to dominate their self-concept, and it is not mundane. People are often puzzled by what they perceive as the genius's self-sacrifice and often egocentric indifference to the needs of others. But the genius's value system, at the core of his or her self-concept, is hardly ever sacrificed for the kind of mundane pleasures and unimaginative goals commonly valued by ordinary persons. Acting on their own values—perhaps one should say *acting out* their self-images—is a notable feature of famous geniuses.

Characteristics of Genius: Some Conclusions

Although this chapter is not meant to provide an exhaustive review of the literature on geniuses and highly creative individuals, it has raised some consistent themes that might be worthy of scientific study. I propose that genius is a multiplicative effect of high ability, productivity, and creativity. Moreover, many of the personality traits associated with genius can be captured by the label "psychoticism." Although geniuses may have a predisposition toward such a disorder, they are buffered by a high degree of ego strength and intelligence. A number of the remaining personality correlates of genius may best be captured by the idea that genius represents an acting-out of its very essence.

Giftedness and Genius: Important Differences

Although giftedness (exceptional mental ability or outstanding talent) is a *threshold* trait for the emergence of genius, giftedness and genius do seem to be crucially different phenomena, not simply different points on a continuum. It has even been suggested that giftedness is in the orthogonal plane to genius. Thomas Mann (1947), in his penetrating and insightful study of Richard Wagner's genius, for instance, makes the startling point that Wagner was not a musical prodigy and did not even seem particularly *talented*, in music or in anything else for that matter, compared to many lesser composers and poets. He was never skilled at playing any musical instrument, and his seriously focused interest in music began much later than it does for most musicians. Yet Mann is awed by Wagner's achievements as one of the world's stupendous creative geniuses, whose extraordinarily innovative masterpieces and their inescapable influence on later composers place him among the surpassing elite in the history of music, in the class with Bach, Mozart, and Beethoven.

It is interesting to note the words used by Mann in explaining what he calls Wagner's "vast genius"; they are not "giftedness" or "talent," but "intelligence" and "will." It is the second word here that strikes me as most telling. After all, a high level of intelligence is what we mean by "gifted," and Wagner was indeed most probably gifted in that sense. His childhood IQ was around 140, as estimated by Catherine Cox (1926) in her classic, although somewhat flawed, study of three hundred historic geniuses. Yet that level of IQ is fairly commonplace on university campuses.

We do not have to discuss such an awesome level of genius as Wagner's, however, to recognize that garden-variety outstanding achievement, to which giftedness is generally an accompaniment, is not so highly correlated with the psychometric and scholastic indices of giftedness as many people, even psychologists, might expect. At another symposium related to this topic, conducted more than twenty years ago, one of the speakers, who apparently had never heard of statistical regression, expressed dire alarm at the observation that far too many students who scored above the 99th percentile on IQ tests did not turn out, as adults, among those at the top of the distribution of recognized intellectual achievements. He was dismayed at many of the rather ordinary occupations and respectable but hardly impressive accomplishments displayed in midlife by the majority of the highly gifted students in his survey. A significant number of students who had tested considerably lower, only in the top quartile, did about as well in life as many of the gifted. The speaker said the educational system was to blame for not properly cultivating gifted students. If they were so bright, should they not have been high achievers? After all, their IQs were well within the range of the estimated childhood IQs of the three hundred historically eminent geniuses in Cox's (1926) study. Although education is discussed in more detail below, the point here is that giftedness does not assure exceptional achievement; it is only a necessary condition.

To reinforce this point, I offer an additional example that occurred on the very day I sat down to write this chapter. On that day I received a letter from someone I had never met, though I knew he was an eminent professor of biophysics. He had read something I wrote concerning IQ as a predictor of achievement, but he was totally unaware of the present work. The coincidence is that my correspondent posed the very question that is central to my theme. He wrote:

> I have felt for a long time that IQ, however defined, is only loosely related to mental achievement. Over the years I have bumped into a fair number of MENSA people. As a group, they seem to be dilettantes seeking titillation but seem unable to think critically or deeply. They have a lot of motivation for intellectual play but little for doing anything worthwhile. One gets the feeling that brains were wasted on them. So, what is it that makes an intelligently productive person?

This is not an uncommon observation, and I have even heard it expressed by members of MENSA. It is one of their self-perceived problems, one for which some have offered theories or rationalizations. The most typical is that they are so gifted that too many subjects attract their intellectual interest and they can never commit themselves to any particular interest. It could also be that individuals drawn toward membership in MENSA are a selective subset of the gifted population, individuals lacking in focus. After all, most highly gifted individuals do not join MENSA.

We must, then, consider some of the ways in which *achievement* contrasts with *ability* if we are to make any headway in understanding the distinction between giftedness (i.e., mainly high *g* or special abilities) and genius. Genius involves actual achievement and creativity. Each of these characteristics is a quantitative variable. The concept of genius generally applies only when both of these variables characterize accomplishments at some extraordinary socially recognized level. Individual differences in countable units of achievement, unlike measures of ability, are not normally distributed, but have a very positively skewed distribution, resembling the so-called J-curve. For example, the number of publications of members of the American Psychological Association, of research scientists, and of academicians in general, the number of patents of inventors, the number of compositions of composers, or the frequency of composers' works in the concert repertoire all show the same J-curve. Moreover, in every case, the J-curve can be normalized by a logarithmic transformation. This striking phenomenon is consistent with a multiplicative model of achievement, as developed and discussed above. That is, exceptional achievement is a multiplicative function of a number of different traits, each of which may be normally distributed, but which in combination are so synergistic as to skew the resulting distribution of achievement. Thereby, an extremely extended upper tail of exceptional achievement is produced. Most geniuses are found far out in this tail.

The multiplication of several normally distributed variables yields, therefore, a highly skewed distribution. In such a distribution, the mean is close to the bottom and the mode generally *is* the bottom. For any variable measured on a ratio scale, therefore, the distance between the median and the 99th percentile is much smaller for a normally distributed variable, such as ability, than for a markedly skewed variable, such as productivity. Indeed, this accords well with subjective impressions: the range of individual differences in ability (*g* or fluid intelligence) above the median level does not seem nearly so astounding as the above-median range of productivity or achievement.

In conclusion, giftedness, a normally distributed variable, is a prerequisite for the development of genius. When it interacts with a number of other critical characteristics, which also are normally distributed, exceptional achievement is produced. Exceptional achievement, however, is a variable that is no longer normal; it is highly skewed, with genius found at the tip of the tail.

Educational Implications

At this point in my highly speculative groping to understand the nature of genius as differentiated from giftedness, I should like to make some practical recommendations. First, I would not consider trying to select gifted youngsters explicitly with the aim of discovering and cultivating future geniuses. Julian Stanley's decision (Stanley, 1977) to select explicitly for mathematical giftedness—to choose youths who, in Stanley's words, "reason exceptionally well mathematically"—was an admirably sound and wise decision from a practical and socially productive standpoint. The latent traits involved in exceptional mathematical reasoning ability are mainly high *g* plus high math talent (independent of *g*). These traits are no guarantee of high productivity, much less of genius. But the threshold nature of *g* and math talent is so crucial to excelling in math and the quantitative sciences that we can be fairly certain that most of the *productive* mathematicians and scientists, as well as the inevitably few geniuses, will come from that segment of the population of which the SMPY students are a sample. Indeed, in Donald MacKinnon's (1962) well-known study of large numbers of creative writers, mathematicians, and architects (certainly none of them a Shakespeare, Gauss, or Michelangelo), the very bottom of the range of intelligence-test scores in the whole sample was at about the 75th percentile of the general population, and the mean was at the 98th percentile (MacKinnon & Hall, 1972).

However, it might eventually be profitable for researchers to consider searching beyond high ability per se and identify personality indices that also will aid in the prediction of exceptional achievement. The proportion of those gifted youths selected for special opportunities who are most apt to be productive professionals in their later careers would thereby be increased. Assuming that high achievement and productivity can be predicted at all, over and above what our usual tests of ability can predict, it would take extensive research indeed to discover sufficiently valid predictors to justify their use in this way. Lubinski and Benbow (1992) have presented evidence that a "theoretical orientation," as measured by the Allport, Vernon, and Lindzey Study of Values, might be just such a variable for scientific disciplines.

Conclusion

Certainly, the education and cultivation of intellectually gifted youths has never been more important than it is today, and its importance will continue to grow as we move into the next century. The preservation and advancement of civilized society will require that an increasing proportion of the population have a high level of educated intelligence in science, engineering, and technology. Superior intellectual talent will be at a premium. Probably there will always be only relatively few geniuses, even among all persons identified as gifted. Yet this is not cause for concern. For any society to benefit from the fruits of genius requires the efforts of a great many gifted persons who have acquired high levels of knowledge and skill. For example, it takes about three hundred exceptionally talented and highly accomplished musicians, singers, set designers, artists, lighting directors, and stage directors, besides many stagehands, to put on a production of *The Ring of the Nibelung*, an artistic creation of surpassing genius. Were it not for the concerted efforts of these performers, the score of Wagner's colossal work would lie idle. The same is true, but on an much larger scale, in modern science and technology. The instigating creative ideas are seldom actualized for the benefit of society without the backup and follow-through endeavors of a great many gifted and accomplished persons. Thus, a nation's most important resource is the level of educated intelligence in its population; it determines the quality of life. It is imperative for society to cultivate all the high ability that can possibly be found, wherever it can be found.

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