Chapter 19
(Im)pure genius—psychoticism, intelligence, and creativity

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1. INTRODUCTION

A defining feature of great creativity is its statistical rarity, which poses a problem for purely sociocultural explanations. While sociocultural theorists might claim that the appearance of the theory of evolution by natural selection became inevitable in the middle of the nineteenth century, no-one claims that the Fifth Symphony would have emerged in the early 1800s whether or not Ludwig van Beethoven existed. Moreover, most lists of "multiple discoveries" (required by Zeitgeist theories) turn out, on examination, to be quite short and do not take notice of important individual contributions (Simonton, 1988). Because Darwin's theory was not identical to Wallace's, the course of biological thought would likely have been very different had Darwin drowned while on the Beagle voyage.

In his masterwork *Genius: The Natural History of Creativity*, Hans Eysenck (1995) proposes that some individuals are more creative than others because they are higher in psychoticism, having a relative excess of dopamine and a relative deficit of serotonin. A moderate degree of psychoticism involves wide associative horizons and overinclusive thinking which facilitate the discovery of remote associations, which is the basis for creative inspiration. Add productivity to creativity and you get achievement, with the term "genius" reserved for work of outstanding achievement. In this chapter I will focus mainly on achievement in science, especially in psychology, where a number of publications and citations (scholarly impact) provide objective indices. Publications require at least a minimum of creativity and large citation counts suggest methodological and theoretical advances.

2. SCIENTIFIC ACHIEVEMENT

It is generally agreed that whereas personality and intelligence are normally distributed, scientific achievement is very abnormally distributed. Only a

relatively few active scientists are responsible for the great majority of creative works. Across disciplines, Dennis (1955) and Shockley (1957) found that the most productive 10% of scientists accounted for 50% of the publications, whereas the least productive 50% accounted for only 15% of the publications. These figures actually underestimate the differences because they only include those who published at least one paper, leaving out of consideration those never making any contribution at all!

Studies of academic psychologists have taken zero producers into account (Endler, Rushton, & Roediger, 1978; Rushton, 1989). Consider, for example, the citation and publication counts reported in Table 19.1. These cumulative percentage frequencies are based on 4070 faculty members studied by Endler et al. in an analysis of the top 100 departments of psychology in the U.S.A., Canada, and the U.K. From Table 19.1 it can be seen that 52% of the sample

Table 19.1. Frequencies and cumulative percentage frequencies for the distribution of citations of and publications by faculty members at the top 100 British, Canadian, and American graduate departments of psychology

	Citations		Publications	
Number of citations or publications	Frequency	Cumulative percentage frequency	Frequency	Cumulative percentage frequency
>100	134	100	—	
26–99	556	97	—	
21–25	164	83	1	100
16–20	223	79	1	99
11–15	338	74	1	99
10	97	65	3	99
9	82	63	4	99
8	102	61	12	99
7	105	58	18	99
6	125	56	37	99
5	187	53	54	98
4	187	48	147	97
3	207	44	259	93
2	302	38	468	87
1	365	31	971	75
0	896	22	2094	52
Total	4070		4070	

Note. From the 1975 Social Sciences Citation Index. (From Endler, Rushton, and Roediger, 1978, p. 1079, Table 5.) Copyright 1978 by the American Psychological Association. Reprinted by permission.

did not publish an article in 1975 in any of the journals reviewed by the *Social Sciences Citation Index*. The picture is similar for citations, the great majority of academic psychologists having relatively few. For example, only about 25% of psychologists had more than 15 citations in 1975 and only 1% had more than 100 citations.

"Agist," "sexist," and "elitist" factors contribute to the positive skew in the distributions. Studies find that productivity increases with age up to around 40–45 years and then gradually diminishes; that women are not only underrepresented in science but, on a per capita basis, produce less than their male counterparts; and that individuals who receive doctorates from more prestigious institutions and/or who get their first academic positions at high-prestige universities are more productive than those who graduate from or are appointed to less esteemed institutions.

As Walberg, Strykowski, Rovai, & Hung (1984) explain, the normal distribution does not apply to exceptional performance. Instead, J-shaped distributions such as those shown in Table 19.1, are characteristic. J-shaped distributions—monotonically decreasing at a decelerating rate—typically arise when the underlying causes combine multiplicatively rather than additively. (Additive causes typically produce normal distributions.) Walberg et al. show that for education, learning is a multiplicative, diminishing-returns function of student ability, time, motivation, and amount and quality of instruction (those instances in which no learning at all takes place occur because any zero score in the equation yields a product of zero).

3. EYSENCK'S THEORY OF CREATIVITY

3.1 Introduction

Eysenck (1995) elaborated on Walberg et al. (1984) and suggested that creative achievement is a multiplicative function of cognitive, personality, and environmental variables as shown in Figure 19.1. Cognitive abilities (such as intelligence, acquired knowledge, technical skills, and special talents) combine with personality traits (such as internal motivation, confidence, nonconformity, persistence, and originality) and environmental variables (such as political–religious, socioeconomic, and educational factors) to produce truly creative achievements. Many of these variables are likely to act in a multiplicative (synergistic) rather than an additive manner. Assuming independence of traits, a scientist who is at the 90th percentile on intelligence, internal motivation, independence, and endurance represents a one in 10,000 combination of all these attributes.

Eysenck follows Galton (1869, 1874) and other early researchers in identifying high intelligence along with "zeal and industry" as primary ingredients of great creativity. Eysenck suggests that intelligence operates primarily through the speed with which new associations are formed. He also

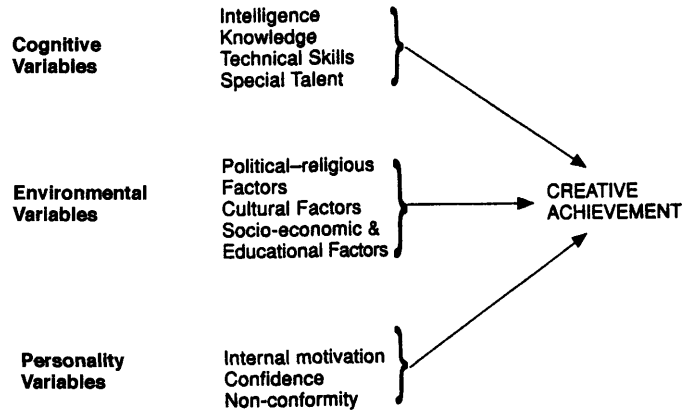

Figure 19.1. Creative achievement as a multiplicative function of cognitive, environmental, and personality variables (from Eysenck, 1995, p. 39, Figure 1.4). Copyright 1995 by Cambridge University Press. Reprinted by permission.

proposes that it is the range of associations available for problem solving that is maximally important and that wideness of range is, in principle, independent of speed. Thus, Eysenck suggests that intelligence and creativity are essentially independent. In earlier work, Eysenck (1983) argued that creativity is significantly related to IQ up to about IQ 120, but after this, becomes independent of IQ. This has also been the view of other reviewers, none of whom downplays the importance of intelligence (e.g., Vernon, 1987).

3.2 The role of psychoticism

Psychoticism is the active ingredient in Eysenck's theory of creativity. Postulated as a fundamental dimension of personality, psychoticism inclines people to all types of abnormal behaviors (see Figure 19.2, and chapter 6). Low scorers on the psychoticism scale are characterized as high in empathy, socialization, and co-operativeness whereas high scorers are seen as cold, egocentric, aggressive, and tough-minded (and given to syndromes such as psychopathy and schizophrenia). Here Eysenck follows the theory that people who are highly original and creative differ from the vast majority in showing behavioral quirks similar to those of schizophrenics and other psychotics. Behavior–genetic studies suggest a common hereditary basis for great potential and for psychopathological deviation (see chapters 6, 12, and 17).

Eysenck credits Bleuler's (1911/1978) description of the schizoid personality for originally linking psychoticism to creativity:

> He [the schizoid] is taciturn or has little regard for the effect on others of what he says. Sometimes he appears tense and becomes irritated by senseless provocation. He

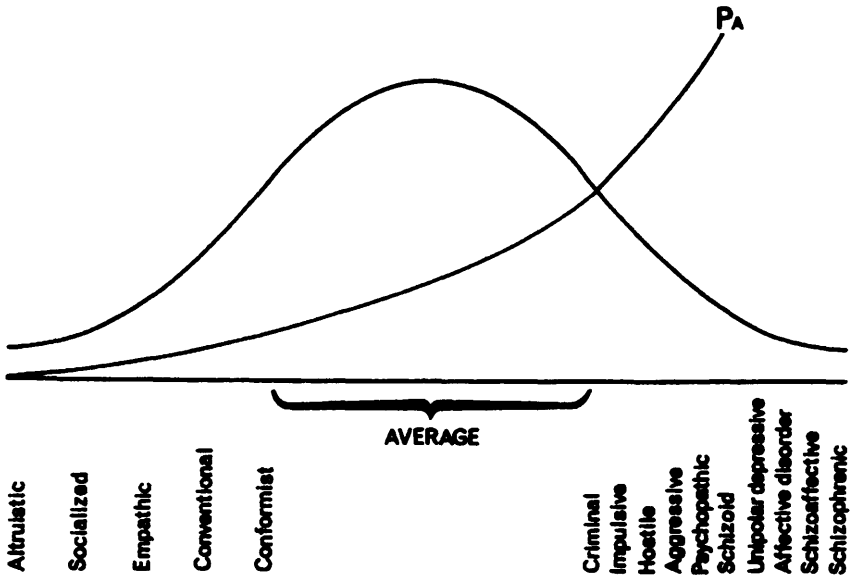

Figure 19.2. Psychoticism as a personality dimension. P_A is the probability of a person at a given position on abscissa developing a psychotic disorder (from Eysenck, 1995, p. 204, Figure 6.1). Copyright 1995 by Cambridge University Press. Reprinted by permission.

> appears as insincere and indirect in communication. His behavior is aloof and devoid of human warmth; yet he does have a rich inner life. In this sense he is introverted ... Ambivalent moods are more pronounced in the schizoid than in others, just as he distorts the meanings of, and introduces excessive doubts into his own concepts. But on the other hand, the schizoid is also capable of pursuing his own thoughts and of following his own interests and drives, without giving enough consideration to other people and to the actual realities of life. He is autistic. The better side of this autism reveals a sturdiness of character, and inflexibility of purpose, an independence, *and a predisposition to creativity*. The worst side of it becomes manifest in a lack of consideration for others, unsociability, a world–alien attitude, stubbornness, egocentricity, and occasionally even cruelty. (Emphasis by Eysenck, 1995, p. 219)

3.3 Overinclusive thinking

But why should people with high psychoticism scores be more creative, that is, have a wide associative horizon? Here Eysenck builds on Cameron's (1947) and Payne, Matussek, & George's (1959) early work linking schizophrenia to "overinclusion" in concept formation and discrimination learning. Schizophrenics fail to maintain normal conceptual boundaries. Rather, they incorporate novel elements, some of them personal, which are merely associated and not essential into their concepts. When a child first hears a

word in a certain context, the word is associated with the entire situation (the stimulus compound). As the word is heard again and again, only certain aspects of the stimulus compound are reinforced. Gradually the extraneous elements cease to evoke the response (the word), having become "inhibited" through a lack of "reinforcement." Thus, "overinclusive thinking" may be the result of a failure of the inhibitory process whereby learned responses like words and concepts are circumscribed, refined, and defined. A flat associative gradient allows the individual a wider interpretation of "relevance" as far as responses to stimuli are concerned. This behavioral pattern has also been described as a "looseness" of thinking or a failure to "filter out" extraneous stimuli.

3.4 Biochemical parameters, latent inhibition and negative priming

Eysenck extends this analysis to include the biochemical studies of Gray, Feldon, Rawlins, Hemsley, & Smith (1991), and N. S. Gray, Pickering, & J. A. Gray (1994), as well as the experimental research on latent inhibition and negative priming among schizophrenics and high scorers on the psychoticism scale. He proposes that dopamine enhances creativity by reducing cognitive inhibition, thereby overextending inclusiveness and so increasing the production of novel combinations. Analogously, serotonin lessens creativity by increasing inhibitory processes. It is the lack of "latent inhibition" in suppressing remote associations that Eysenck proposes gives high psychoticism its creative edge. Obviously psychotic thoughts differ from creative ones, so additional cognitive characteristics including focused reasoning, general intelligence, strong motivation, ego-strength, and the other variables listed in Figure 19.1, come into play.

Several empirical studies have confirmed the relationship between psychoticism and creativity. Woody and Claridge (1977) administered the psychoticism scale from the Eysenck Personality Questionnaire and five tasks from the Wallach–Kogan Test of Divergent Thinking (e.g., name all the things you can think of that move on wheels; Ss responded with items such as "ball-point pens," and "can openers") to 100 university students. Psychoticism correlated from 0.32 to 0.45 ($p < 0.05$) with the "total" number of responses produced and 0.61–0.68 for the number of "unique" responses. No reliable correlations were found between creativity and extraversion and neuroticism, but the lie-score, which correlates negatively with psychoticism and is partly a measure of social conformity, showed consistent negative correlations with the creativity scores.

In a study of Canadian university students, Rushton (1990) replicated Woody and Claridge's (1977) correlation between psychoticism and creativity. Rushton also showed that creativity scores correlated with IQ. Using real-life criteria, 337 professional artists with a record of holding successful exhibits,

were administered the Eysenck Personality Questionnaire and found to have higher scores on the psychoticism scale than nonartists (K. O. Gotz & K. Gotz, 1979a; 1979b).

4. PSYCHOTICISM AND "THE MAD SCIENTIST"

4.1 Review of the literature

The portrayal of the "scientific personality" in some biographies leaves little doubt as to what characterizes the ideal scientist: objectivity, emotional neutrality, rationality, open-mindedness, superior intelligence, integrity, and a communal, open, and co-operative attitude toward sharing knowledge. Indeed, sometimes the history of science is "as inspiring in its human values as are the legends of the Saints" (Knickerbocker, 1927, p. 305).

Eysenck provides many biographical vignettes that document the gap between reality and this idealized portrait. Scientists often engage in emotionally charged ideological battles, where personal success and the destruction of opponents are more important than objectivity, where selective perceptions and distortion of facts qualify the notion of rationality, and where personal biases lead to editorial rejection of contrary ideas. Outright deception and fraud mar the ideal of honest integrity, and secrecy, suspicion, and aggressive competition in the race to be "number one" are as manifest as any altruistic desire to share knowledge and cooperate. Nonetheless, some inspirational qualities do come through, as in Eysenck's examples of "unconquerable will" and achievement (as exemplified by George Washington Carver who was born a slave but rose against the odds to considerable heights of scientific achievement—see chapter 15).

The investigation into the psychological characteristics of eminent scientists began with Francis Galton (1869, 1874). His pioneering work was expanded by Cattell (1903, 1910), Havelock Ellis (1904), Cox (1926), Roe (1952), Cattell and Drevdahl (1955), Terman (1955), and by Taylor and Barron (1962), and others (see Jackson & Rushton, 1987, and Sulloway, 1996, for reviews). From this growing body of research it became clear that successful scientists are not at all "Saint-like" in either their personality or work style. They often display reclusive personalities, arrogant work styles, hostile responses to frustration, and intrinsic motivations bordering on autism.

For instance, Terman's (1955) longitudinal study of 800 high-IQ men found that those who took science degrees at college differed from nonscientists in showing great intellectual curiosity from an early age and in being lower in sociability than average. Terman concluded that "the bulk of scientific research is carried on by devotees of science for whom research is their life and social relations are comparatively unimportant" (p. 7). Cited is the work of Roe (1952), who found scientists to have difficulty in interpersonal situations and to often try to avoid them. Terman described Roe's sample of scientists as tending

"to be shy, lonely, slow in social development, and indifferent to close personal relationships, group activities, or politics" (p. 7; see chapter 20 for details). Terman noted that such traits were not necessarily defects of personality, for emotional breakdowns were no more common than among nonscientists. Instead, he suggested that a below-average interest in social relations and a heavy concentration of interest in the objective world was a normal departure from average that was decidedly favorable for the professional development of a scientist.

Cattell's (1962, 1965) and Cattell and Drevdahl's (1955) profile of the prototypic scientist emerges from both the qualitative study of biographies and from quantitative psychometric studies of leading physicists, biologists, and psychologists. Cattell found successful scientists to be reserved and introverted, intelligent, emotionally stable, dominant, serious-minded, expedient, venturesome, sensitive, radically thinking, self-sufficient, and having a strong and exacting self-concept. He noted that the physicists, biologists, and psychologists were similar in personality except that psychologists were less serious-minded and more "surgent" and talkative than nonpsychologists. Creative scientists differed most from normals on schizothymia–cyclothymia factor, with scientific researchers being toward the schizothymic end. Cattell thus describes scientists as being skeptical, internally preoccupied, precise, and critical individuals who are exacting and reliable.

Several studies were carried out by Barron and his colleagues (Barron, 1962; Taylor & Barron, 1962). Barron, for example, found creative people generally to be cognitively complex (preferring complexity and imbalance in phenomena), to have a more differentiated personality structure, to be independent in their judgment and less conformist in social contexts such as the Asch group pressure situation, to be self-assertive and dominant, and to be low in using suppression as a mechanism for the control of impulses and thoughts (that is, they forbade themselves fewer thoughts). Chambers (1964) compared eminent researchers with those not so eminent but matched on other relevant variables. Results indicated that the more creative scientists were also more dominant, had more initiative, were more self-sufficient, and were more motivated toward intellectual success. McClelland (1962) found successful scientists to be not only higher in need for achievement but also to be calculating risk-takers in the same way as are successful business entrepreneurs. The risk-taking, however, involved dealing with nature or physical situations rather than social situations, for he, too, found scientists to be decidedly avoidant of interpersonal relationships. Scientists, for instance, indicated a much higher preference for being a lighthouse keeper as opposed to being a headwaiter (Item no. 324 on the Strong Vocational Interest Blank). McClelland also argued that the need for scientific achievement was a strong aggressive drive "which is normally kept carefully in check and diverted into taking nature apart" (1962, p. 162). In short, the scientist is "introverted and bold" (Drevdahl & Cattell, 1958).

Studies of psychologists have found that publication and citation counts can be predicted by those components of achievement motivation that concern the enjoyment of challenging tasks and hard work, but not by those components concerned with interpersonal competition or bettering others (Helmreich, Beane, Lucker, & Spence, 1978; Helmreich, Spence, Beane, Lucker, & Matthews, 1980). Type A "workaholic" behavior (aggressive, incessantly struggling, time-oriented, hostile when frustrated) predicts the number of citations a psychologist's work earned from others (Matthews, Helmreich, Beane, & Lucker, 1980). Using structural equation modeling, Feist (1993) found a good fit leading from hostile personality, internal motivation, and arrogant working style to objectively measured eminence in 100 physicists, chemists, and biologists at major research universities in California.

Rushton, Murray, and Paunonen (1983) examined the relation of 29 personality traits to research and teaching effectiveness composites (which intercorrelated zero) in two independent samples of Canadian university professors. The cluster of traits associated with being an effective researcher differed from those characterizing the effective teacher. As indicated in Figure 19.3, the attributes of the successful researcher were less socially desirable than those associated with being a good teacher (ambitious, enduring, dominant, aggressive, independent, and demanding definiteness versus liberal, sociable, extraverted, and supportive; indeed, good researchers were characterized as less "objective" than good teachers and more defensive and authoritarian). The only variables loading positively on both dimensions were intelligence and leadership, while meekness suggested being poor in both. Although this study was not carried out to test Eysenck's theory, it seems that successful researchers are high on high psychoticism characteristics.

4.2 New evidence

To test whether the profile of the successful researcher in Rushton et al.'s (1983) study did conform to high psychoticism, I sought Professor Eysenck's help in weighting each of the 29 traits used (see Table 19.2) from −3 (strong negative correlation with psychoticism) to +3 (strong positive correlation with psychoticism).

Although I published this follow-up study in Personality and Individual Differences (Rushton, 1990) and although the results confirmed Eysenck's theory of creativity, the study was inexplicably overlooked in the literature reviewed for the Genius book! This therefore provides me with an especially good justification for re-reporting those data again here!

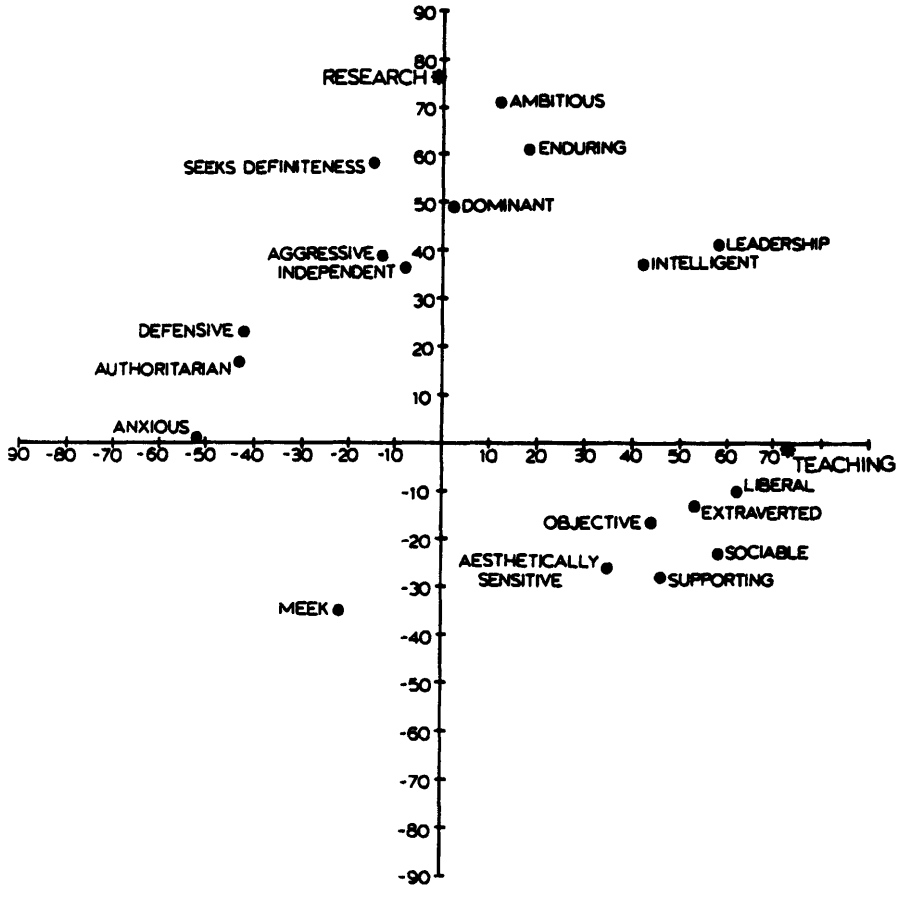

Figure 19.3. Plot of mean factor pattern coefficients of personality traits on dimensions of research productivity and teaching effectiveness, averaged across two studies. Only those trails with absolute values of >.30 on either factor in both studies are shown. (Based on data in Rushton et al., 1983.)

5. PSYCHOTIC PROFESSORS?

In the first of the two studies, the participants were 46 male and six female full-time psychology professors at the University of Western Ontario. (Due to the small number of females, all analyses are collapsed across sex.) Each professor was assessed on 29 traits using four techniques: faculty–peer ratings, student-ratings, self-ratings, and self-report-questionnaires (Rushton et al., 1983). Ratings were made on nine-point scales, using the trait names and brief descriptions shown in Table 19.2, which also shows the split-half reliabilities for the faculty-peer and student judgments. Instructions emphasized that ratings

Table 19.2. Split-half reliabilities of peer and student ratings of personality computed across Professor targets for each of 29 personality traits (decimals omitted). Also shown is the weighting assigned to the trait for its loading on psychoticism (P)

Personality trait and trait definition	Raters		P Weighting
	Faculty (n = 52)	Students (n = 43)	
1. Meek (mild mannered; subservient)	73	57	−3
2. Ambitious (aspiring to accomplish difficult tasks; striving, competitive)	88	74	+1
3. Sociable (friendly, outgoing, enjoys being with people)	74	63	−2
4. Aggressive (argumentative, threatening; enjoys combat and argument)	84	62	+3
5. Independent (avoids restraints; enjoys being unattached)	80	42	+2
6. Changeable (flexible, restless; likes new and different experiences)	77	33	0
7. Seeks definiteness (dislikes ambiguity or uncertainty in information; wants all questions answered completely)	84	22 ns	+1
8. Defensive (suspicious, guarded, touchy)	72	56	+3
9. Dominant (attempts to control environment; forceful, decisive)	87	60	+2
10. Enduring (willing to work long hours; persevering, steadfast, unrelenting)	90	52	0
11. Attention seeking (enjoys being conspicuous, dramatic, colorful)	88	67	+1
12. Harm avoiding (careful, cautious, pain-avoidant)	84	90	−2
13. Impulsive (spontaneous, hasty, impetuous, and uninhibited)	89	31	+3
14. Supporting (gives sympathy and comfort; helpful, indulgent)	84	36	−3
15. Orderly (neat and organized; dislikes clutter, confusion, lack of organization)	77	56	−1
16. Fun loving (playful, easygoing, light-hearted; does many things "just for fun")	88	75	0
17. Aesthetically sensitive (sensitive to sounds, sights, tastes, smells)	80	74	0
18. Approval seeking (desires to be held in high esteem; obliging, agreeable)	76	42	−2
19. Seeks help and advice (desires and needs support, protection, love, advice)	80	86	−2
20. Intellectually curious (seeks understanding; reflective, intellectual)	78	65	0
21. Anxious (tense, nervous, uneasy)	60	63	0
22. Intelligent (bright, quick, clever)	89	50	0
23. Liberal (progressive, seeks change, modern, adaptable)	81	29 ns	0
24. Shows leadership (takes initiative and responsibility for getting things done)	86	54	0
25. Objective (just, fair, free of bias)	78	48	0
26. Compulsive (meticulous, perfectionistic, concerned with details)	69	50	0
27. Authoritarian (rigid, inflexible, dogmatic, opinionated)	70	52	0
28. Extraverted (has many friends; craves excitement; fond of practical jokes; is carefree, easygoing, optimistic)	90	71	0
29. Neurotic (a worrier; overly emotional; anxious, moody, and often depressed)	61	71	0
Mean	79	56	

Note. From Rushton (1990, p. 1079, Table 5).

were to be made relative to other professors rather than to people in general. There was an average of 12 ratings per faculty member.

The various personality assessments showed convergent validity with the scores on self-ratings and questionnaires averaging 0.52 across the 29 traits and the ratings made by faculty peers and by students averaging 0.43. Because the return rates for the peer-ratings ($n = 52$) were higher than for other procedures, the analyses will be limited to these. The ratings were combined using Professor Eysenck's assigned weights (shown in Table 19.2) to produce a psychoticism score.

An index of creativity was made from two measures of research effectiveness: (1) total publications over the previous four years as listed in either the Social Science Citation Index or the Science Citation Index (whichever was larger for the particular individual and with credit assigned equally for senior and junior authorship); and (2) total citations for the previous three years in the same Citation Indices (with first authored self-citations excluded). Year-to-year stability was 0.60 for publications and 0.98 for citations. The two indices intercorrelated 0.28 ($p < 0.05$) and were combined (using averaged standard scores). The correlation between psychoticism and creativity was 0.40 ($p < 0.01$).

A follow-up study using a mail survey was made at nine other psychology departments in Canada with 69 (68 male, one female) people responding (Rushton et al., 1983). The same 29 personality traits and definitions as in study 1 were used. Respondents were instructed to rate themselves in percentiles, "relative to other Canadian university psychology professors." The distributions turned out to be roughly normal, with a mean percentile across traits of 55 and a standard deviation of 21. Socially desirable traits were rated higher than socially undesirable traits, with professors rating themselves at the 80th percentile on intelligence and at the 26th percentile on authoritarianism! Four items were aggregated to index creativity: (1) total number of publications; (2) mean number of publications in last five years; (3) number of hours spent on research; and (4) rated enjoyment of research. Each of these was significantly associated with the others (mean correlation of 0.36; $p < 0.01$). Psychoticism correlated with creativity 0.43 ($p < 0.01$).

6. ACTS OF DESTRUCTION

The two studies presented of Canadian university professors confirm Eysenck's predicted relationship between psychoticism and creativity although they were silent about the mechanisms involved. However, personality traits must exert their effects either through the cognitive system or through the social system. As reviewed, Eysenck proposes that psychoticism works principally by widening an individual's associative network available for problem solving.

Eysenck's (1995) psychology of creativity will likely go on to become another "citation classic." To this reviewer, it is difficult to find criticism to offer, for Eysenck seems so very right about so very much! Rather than criticism, therefore, I will highlight some topics that struck me as in some ways paradoxical and so perhaps especially worthy of future study—the role of intelligence, motivation, values, and the social management of research teams, bureaucracies, and public relations.

Several reviewers have concluded that creativity is significantly related to IQ up to about IQ 120 (the level of an average North American university undergraduate). Beyond IQ 120, creativity becomes independent of IQ (Eysenck, 1983; Vernon, 1987). Because little evidence is provided for this claim, it may be premature. Individuals with IQs of 120 would have great difficulty competing successfully in some of today's most creative scientific professions (astrophysics, computer engineering, mathematics). Moreover, the importance of general cognitive ability has now been shown in literally hundreds of studies to predict work performance in all occupations, whether measured by supervisor ratings, training success, job knowledge, work sample, or ongoing job learning, with validities as high as $r = 0.80$ (see Herrnstein & Murray, 1994, for review). Many of these studies were carried out on very large samples by the U.S. Employment Service and the U.S. Armed Services examining jobs rated as of low, medium, and high complexity, or categorized as clerical, professional, or technical. Meta-analyses showed that general cognitive ability, rather than specific cognitive aptitudes or job knowledge, was the best predictor of performance in all cases. Typically, as the complexity of the job increases, the better cognitive ability predicted performance (e.g., managers and professions 0.42–0.87, sales clerks and vehicle operators 0.27–0.37; e.g., Hunter, 1986, Table 1).

Arousal and motivation constitute another topic where evidence is conflicting (Eysenck, 1995, pp. 267–270). Based on biographies, low arousal and even dream-like reveries are often associated with many acts of creation; and experimental studies dovetail by showing that high arousal narrows attention. Yet creative people are also often anxious and introverted and so are more aroused than average. Eysenck concludes that perhaps the supreme act of creation occurs during low arousal—and that high arousal accompanies the elaboration stage, when creative people attempt to prove their intuitive insights, argue with skeptics, and so on.

Eysenck's distinction makes sense, but new attention might be given to the obsessive–compulsive and highly aroused nature of much creativity. As Jensen (1996) has pointed out, the ordinary term "motivation" explains little and seems too intentional and self-willed to fit the behavior of geniuses whose biographies show 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. Instead, Jensen likens "mental energy" in geniuses to the kind of cortical arousal seen under the influence of stimulant drugs. Jensen elaborates on a clue offered by Havelock Ellis (1904) that eminent men suffered from gout—a painful inflammation, usually of the joint in the big toe, caused by the formation of uric acid crystals. Dozens of studies (reviewed by Jensen & Sinha, 1993) show that although serum urate level (SUL) is slightly correlated with intelligence, it is much more highly correlated with achievement and productivity. For instance, among high school students there is a relation between scholastic achievement and serum urate level, even after controlling for IQ. Another study found a correlation of 0.37 between serum urate level and the publication rates of university professors (Mueller & French, 1974). One explanation is that the molecular structure of uric acid is similar to caffeine and therefore acts as a brain stimulant. This energy, combined with very high intelligence or an exceptional talent, results in high productivity.

Another aspect of the motivational structure of geniuses identified by Jensen from biographical material is a powerful value system that channels and focuses the individual's mental energy. It is not something mundane, but seems to control the direction of personal ambition and the persistence of effort and also seems at odds with some aspects of the psychopathic character implied earlier. People are often puzzled by what they perceive as the genius's self-sacrifice of his other needs (as well as to his often egocentric indifference to the needs of others). But the genius's value system, at the core of the self-concept, is hardly ever sacrificed for the typical pleasures of ordinary persons. Acting on their own values—perhaps one should say acting-out their self image—is a notable feature of famous geniuses.

A less surprising proclivity, often manifested at an early age, is unusually strong and long-lasting curiosity and exploratory behavior. Charles Darwin himself stated in his autobiography (Barlow, 1958 p. 141) that he had always had the strongest desire to understand and explain whatever he observed, that is, to group all facts under some general laws. A perhaps related "superego" trait is a concern for excellence, and especially for "elegant, virtuous, and beautiful solutions." [I am indebted to Jackson (1987) for some of the discussion in this and the next section.] Achieving "virtuous" solutions (Robert Oppenheimer's poetic phrase) requires long hours of arduous work mastering complex and sometimes recalcitrant problems. Searching for beauty and virtue is a quite different view of research than that taken by the typical corporate financial officer or university administrator, who see research as a means to the end of either profits or enhanced institutional prestige.

To summarize Eysenck (1995), Jensen (1997), and others on great scientists:

$$\text{Genius} = \text{Ability} \times \text{Productivity} \times \text{Creativity} \times \text{Values} \times \text{Curiosity}$$

where Ability = intelligence and information processing efficiency; Productivity = endogenous cortical stimulation; Creativity = trait psychoticism; Values = central motivating mechanisms for honest, beautiful, and virtuous solutions; and Curiosity = the search for general laws. Even the above list of synergistic traits is not exhaustive.

Managing the social world of science is a much neglected topic but obviously calls for another set of traits, especially in the increasingly complicated, high-tech, bureaucratized world of "Big Science." Major innovations need to be "sold" through networking and social organizations, including government bodies, the mass media, funding agencies, and scientific and professional groups. Perhaps high-psychoticism scorers are less vulnerable to social blandishments and criticisms. But it would be a mistake to fixate on maverick and hostile Don Quixotes tilting at establishment windmills. Because a fairly clear personality profile of the innovative researcher emerges, it does not mean that individual differences do not exist! For example, as Cattell (1962) noted, although many scientists have historically been recognized as less sociable than average, Galileo, Leibnitz, and others were as fully at home in the social free-for-all of court circles as in the laboratory. Far from thinking that the optimal condition for scientific advance is absolute freedom to think in a far removed-from-it-all environment, evidence (e.g., Pelf, 1967; reviewed in Jackson, 1987) suggests that social constraints, and constructive social interaction are beneficial.

Many of the more exciting episodes in science (some discussed in Eysenck) occur when a scientist lives to see himself overthrowing (or at least going well beyond) established thinking. Here Charles Darwin again comes immediately to mind. The converse is similarly fascinating, as when the establishment overthrows the scientist! Here a good example is Ignaz Philipp Semmelweis who failed to persuade the medical establishment of Hungary that washing hands in hospitals saved lives (Eysenck, 1995, pp. 150–153). Darwin's brilliant orchestration of his output and ability to attract loyal and powerful advocates contrasts with Semmelweis's intemperate, self-destructive, and counter-productive behavior. The role of marshaling public relations to win scientific battles against great odds needs much further investigation. [A recent book by Duesberg (1996) is a masterpiece of describing how the majority of scientists who believed that AIDS is caused by a virus energized the entire scientific community behind them leaving heretics like Duesberg out in the cold.] Personally I am intrigued by the "antiscientific" revolution led by Franz Boas who almost single-handedly succeeded in decoupling social science from Darwinian thinking (cf. Rushton, 1995). Boas must have been a public-relations genius ... especially given that so much of what he had to say turns out to be so false!

Genius, including evil genius (your pick) clearly needs more study! Acts of genius are acts of creative destruction (destroying old theories, time-honored beliefs, and prejudices). We need to learn how to foster creativity and live with the concomitant destruction.

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