Part III. PERSONAL CHARACTERISTICS THAT CONTRIBUTE TO GREATNESS AS A PSYCHOLOGIST

Presumably, individual differences in output and impact are ultimately grounded in the psychological characteristics of the psychologists. In other words, great psychologists differ from their less-renowned colleagues on the basis of various personal attributes that contribute in some way to creative productivity.

Chapter 6. Cognition

One obvious possibility is that the attainment of distinction depends on the possession of exceptionally high degrees of intellectual ability. After investigating the psychometric and historiometric research on this question, I turn to another possibility, namely that it depends on specific mental strategies and processes. I conclude with a discussion of how the impact of three cognitive attributes – intelligence, imagery, and versatility – vary across scientific disciplines. Do great psychologists think like other great scientists?

Two issues:
First, we can examine the repercussions of individual differences in general information-processing power – most commonly styled intelligence.
Second, we can scrutinize what specific cognitive processes and strategies contribute most to making notable contributions to psychological science.

EMINENCE AND INTELLIGENCE
Samuel Johnson (1781), the author of the first English dictionary, held that "the true Genius is a mind of large general powers, accidentally determined to some particular direction" (p. 5).

- Spearman's *g*, the general factor of human intelligence, supposed to underlie performance on a variety of intellectual tasks (Gottfredson, 1997).
- General intelligence, as measured by some standardized "IQ test" loading high on *g*, will provide a consistently valid predictor of occupational attainments in a diversity of domains (e.g., Barrett & Depinet, 1991; Ree, Earles, & Teachout, 1994).
- Hence, it is likely that great psychologists are smart psychologists, in the sense of placement at the upper end of the distribution in general intelligence.

Evidence for this conjecture comes from two sources:

1. psychometric studies, and
2. historiometric investigations.

Psychometric Inquiries

History:

- Francis Galton (1869)
- Galton (1883)
- Alfred Binet, in collaboration with Theodor Simon
- Leta Hollingworth (1926, 1942)
- Lewis M. Terman (1917, 1925).
    - *American Heritage Electronic Dictionary* (1992) a genius is "a person who has an exceptionally high intelligence quotient, typically above 140."
    - Stanford-Binet scale
    - *Genetic Studies of Genius*

Applications: Direct and indirect assessments

Direct assessments.

Many studies show that successful scientists tend to have IQ scores much higher than average.

- E.g., Institute for Personality Assessment and Research (IPAR) at UCB.
    - Creative mathematicians averaged a 135 IQ on the Wechlser Adult Intelligence Scale, WAIS (Helson & Crutchfield, 1970),
    - Creative research scientists averaged WAIS IQ scores of 133 (MacKinnon & Wallace, 1972), meeting the standard for joining Mensa (Serebriakoff, 1985).
- Other researchers report IQ scores at least this high (e.g., J. Gibson & Light, 1967), and sometimes even higher (e.g., Roe, 1953a). Eminent psychologists do not substantially differ from other scientists in their intellectual power (Roe, 1953a).

However, two reservations:

- First, the range in the IQ scores received is wide, so that many distinguished scientists exhibit a psychometric intelligence no higher than that of the average college graduate (e.g., around IQ 120). At IPAR the range for creative research scientists ranged from 121 to 142, albeit nearly three fourths had WAIS IQs greater than or equal to 130 (MacKinnon & Wallace, 1972).
- Second, the range is so great that the IQ distributions for eminent scientists differ very little from those from their less eminent colleagues.
    - In the IPAR studies the mean WAIS IQ scores for a comparison group of scientists was only one point lower (i.e., 133 versus 132), a negligible difference (MacKinnon & Wallace, 1972).
    - Moreover, when IQ scores are correlated with some valid criterion of scientific distinction, the correlations are nearly zero.
        - One study of 499 academic researchers in the physical, biological, and social sciences found that IQ correlated .05 with the number of published papers and .06 with the number of citations (S. Cole & J. R. Cole, 1973).
        - Another study of research scientists actually found a slightly negative correlation (r = -.05) between intelligence and a citation measure of scientific achievement (Bayer & Folger, 1960).
        - The same near-zero correlations appear if a different criterion of scientific accomplishment is used, such as ratings by peers and supervisors (e.g., r = -.05, in Gough, 1976).

Although none of the above investigations singled out psychologists for special treatment, there is no prima facie reason to think that attainment in psychology operates by some principle fundamentally different than the rest of the sciences. Indeed, if an instrument devised by psychologists *only* predicted the differential achievement of psychologists, then one would have to seriously consider whether IQ tests have anything more than parochial value.

Indirect assessments.

Explanations for such dismal predictive validities:

- Perhaps IQ bears a curvilinear relation with achieved eminence so that someone can be *too smart* to do good psychology, a possibility that is known to hold for certain leadership domains (Simonton, 1985a, 1995c).
- Alternatively, intelligence may operate so that once individuals surpass a certain minimal threshold level, such as an IQ of 120, further increases do not necessarily translate into greater achievement (Barron & Harrington, 1981; Simonton, 1999d).
- But another possibility is more critical: Perhaps the IQ tests that developed from Binet's landmark measure are no more relevant to exceptional achievement than were Galton's abortive anthropometric instruments.

There exist more subtle approaches to assessing a person's intelligence than to have him or her sit down and answer the questions typical of the IQ test.

- One alternative is simply to ask colleagues to rate a scientist's intelligence and then determine whether this predicts achievement.
    - In one investigation, for instance, the faculty-peer assessed intelligence of 52 fulltime psychology professors correlated .40 with a composite measure of publication and citation counts (Rushton, 1990). Although this might seem to contradict what was found using IQ tests, it is not unlikely that peer-rated intelligence is somewhat confounded with the achievement measure. Colleagues will have some idea of the more productive members of their faculty, and this may influence their evaluation of a colleague's intelligence, inflating the true correlation.
    - A related investigation looked at the same achievement criterion for a sample of 69 Canadian psychologists, only this time using self-ratings of intelligence as the predictor (Rushton, 1990). The correlation was essentially zero ($r = .05$), suggesting, perhaps, that psychologists are not always the most dependable judges of their own capacities. Not only may some overrate themselves, for underratings are possible, too.
- Yet another indirect approach is to assess integrative complexity (Suedfeld, Tetlock, & Streufert, 1992). Two applications stand out.
    - The first inquiry found that the presidential addresses delivered by highly eminent APA presidents scored higher in integrative complexity than did those delivered by less eminent presidents (Suedfeld, 1985). Similarly, the more productive among the APA presidents were more complex than those less productive.
    - The second inquiry scored interviews in which a sample of physicists, chemists, and biologists talked about their research and teaching (Feist, 1994). The complexity with which a scientist spoke about his research correlated .25 with total citations and .20 with peer-rated eminence. However, the complexity reflected in that part of the interview in which a scientist spoke about his teaching correlated *negatively* with the total number of works that were cited in the professional literature ($r = -.21$; Feist, 1994). Hence, if the integrative complexity measure does indeed tap individual differences in intelligence, it is doing so in a task-specific manner incompatible with the notion of Spearman's *g*.

The most secure conclusion to be drawn from the direct and indirect measures is that great psychologists are certainly not less intelligent than their more obscure colleagues. The greats might even be slightly more intelligent. But the effect size is never large for any variety of psychometric measure. Do the historiometric assessments yield the same general conclusion?

Historiometric Inquiries

Volume 2 of Terman's classic *Genetic Studies of Genius*: Catharine Cox's (1926) *The Early Mental Traits of Three Hundred Geniuses*.

Extension of Terman (1917): Galton learned his capital letters by the time he was 12 months old, and added the lower-case alphabet 6 months later; learning to read at 2.5 years of age, and being able to sign his name before he was 3, he could write without assistance in his 4th year. He wrote the following letter to his older sister just before his 5th birthday:

> MY DEAR ADÈLE,
>
> I am 4 years old and I can read any English book. I can say all the Latin Substantives and Adjectives and active verbs besides 52 lines of Latin poetry. I can cast up any sum in addition and can multiply by 2, 3, 4, 5, 6, 7, 8, [9], 10, [11].
>
> I can also say the pence table. I read French a little and I know the clock.
>
> FRANCIS GALTON,
>
> Febuary 15, 1827.
>
> (Cox, 1926, p. 42)

Galton's IQ was close to 200.

Cox improved upon Terman's exploratory investigation:

- she rendered the methodology far more sophisticated.
- she introduced many important statistical refinements, such as the calculation of reliability coefficients for her IQ estimates.
- she studied an unusually large sample taken from Cattell (1903).

The next step was the most laborious.

- Cox compiled for each individual the necessary biographical data, which a team of independent raters then used to provide IQ estimates.
- Two estimates were calculated, one for ages 0-16 and the other for ages 17-26.
- Cox calculated reliability coefficients that were used to provide "corrected" IQ estimates.

Table 6.1 shows the results for those among the 301 who also have figured prominently in psychology's history (according to Annin, E. G. Boring, & R. I. Watson, 1968).

Table 6.1
Uncorrected and Corrected IQ Scores and Reliabilities for Ages 0-16 and 17-26

	Uncorrected		Reliabilities		Corrected	
Name	**0-16**	**17-26**	**0-16**	**17-26**	**0-16**	**17-26**
J. S. Mill	**190**	**170**	**.82**	**.82**	**200**	**180**
Goethe	**185**	**200**	**.82**	**.82**	**190**	**210**
Leibniz	**185**	**190**	**.75**	**.75**	**195**	**205**
Pascal	**180**	**180**	**.75**	**.75**	**190**	**195**
A. von Haller	**175**	**180**	**.82**	**.82**	**180**	**190**
Voltaire	**170**	**180**	**.75**	**.75**	**180**	**190**
Hume	**155**	**160**	**.60**	**.60**	**175**	**180**
Berkeley	**150**	**175**	**.60**	**.75**	**170**	**180**
Comte	**150**	**170**	**.60**	**.75**	**170**	**185**
Descartes	**150**	**160**	**.53**	**.60**	**165**	**180**
Diderot	**150**	**145**	**.60**	**.60**	**165**	**165**
Galileo	**145**	**165**	**.53**	**.60**	**160**	**185**
F. Bacon	**145**	**155**	**.53**	**.53**	**165**	**180**
Kepler	**140**	**160**	**.53**	**.75**	**155**	**175**
Hegel	**140**	**145**	**.43**	**.43**	**165**	**165**
Montaigne	**140**	**140**	**.60**	**.43**	**155**	**165**
Hobbes	**140**	**135**	**.43**	**.43**	**175**	**180**
Kant	**135**	**145**	**.60**	**.60**	**175**	**180**
C. Darwin	**135**	**140**	**.43**	**.53**	**155**	**165**
Newton	**130**	**170**	**.43**	**.60**	**150**	**190**
Spinoza	**130**	**145**	**.20**	**.43**	**170**	**175**
Rousseau	**130**	**125**	**.53**	**.53**	**150**	**150**
Linnaeus	**125**	**145**	**.43**	**.60**	**155**	**165**
Locke	**125**	**135**	**.43**	**.43**	**150**	**165**
Harvey	**120**	**150**	**.20**	**.43**	**170**	**165**
Copernicus	**105**	**130**	**.11**	**.43**	**135**	**160**

***Note*. The uncorrected and corrected estimated IQ scores and their reliabilities are taken from the entries for each of the notables reported in Cox (1926).**

Top of this list is J. S. Mill, who began to learn Greek at 3, reading Plato at 7, and studying the Greek classics until age 9; he was also studying his history, so that he could discuss the relative military prowess of Marlborough and Wellington when he was 5, and wrote a history of Rome at 6½; beginning the study of Latin at 8, he was reading the Latin classics within a year; also at 8 he began his mathematical studies with geometry and algebra, a near later advancing to conic sections, spherics, and Newton's arithmetic, so by age 11 he could begin the calculus (Newton's fluxions); still continuing his classics studies, he wrote a synoptic table of Aristotle's *Rhetoric* at the same time, and at age 12 moved on to philosophy and logic, taking on political economy in the following year; at 14 he began reading French authors; he rounded out his first 16 years by commencing his law studies.

Cox (1926) directly calculated the relation between IQ and eminence: Using the uncorrected IQ for 17-26 and Cattell's published rankings, .25; the partial correlation, controlling for reliability, .16. Partialling out other variables, such as birth year, the association becomes reduced a bit more ($\beta = .14$). So the results are starting to appear more comparable to what was found using psychometric measures – either a null association or one only slightly positive. Nonetheless, it must be recognized that Cox's 301 form a highly select group in terms of eminence. Historiometric studies of political leaders have found respectable linkages between eminence and intelligence when the former variable is allowed to vary more (i.e., by including exemplars of truly incompetent leadership).

Finally, it must not be overlooked that these 301 geniuses define a very bright group of people. The average corrected IQ for the 0-16 age period is 153, which is two points higher than for the Termites. Better yet, the average corrected IQ for the 17-26 period is 164, which is the same level as the criterion for joining the Four Sigma Society of super-intelligent individuals.

MENTAL STRATEGIES AND PROCESSES

Herbert Simon et al.:

- computer models of the discovery process that purport to simulate the manner in which real discoveries were made (Langley, H. A. Simon, Bradshaw, & Zythow, 1987; also see Shrager & Langley, 1990);
- OCCAM, BACON, GALILEO, and DALTON;
- e.g., BACON rediscovered Kepler's Third Law of planetary motion, Black's Law of temperature equilibrium, Ohm's Law of current and resistance, Prout's hypothesis of atomic structure, the Gay-Lussac Law of gaseous reaction, Dulong-Petit Law of atomic heats, and the derivation of atomic weights by Avogadro and Cannizzaro (Bradshaw, Langley, & H. A. Simon, 1983).
- Helps explain why intelligence has such a minimal association with achieved eminence in the sciences.
- This work by Herbert Simon and his colleagues continues a long philosophical tradition.

Not all psychologists believe that these cognitive models can capture the rich complexity of the discovery process in high-impact science.

- e.g., the commonplace claim that scientists proceed by the deliberate formulation and rejection of hypotheses (e.g., Popper, 1959). Howard Gruber (1974) had this to say after extensive examination of Darwin's notebooks:
  The picture of scientific thought is often painted as being carried forward by the construction of alternative hypotheses followed by the rational choice between them. Darwin's notebooks do not support this rationalist myth. Hypotheses are discovered with difficulty in the activity of a person holding *one* point of view, and they are the expression of that point of view. It is hard enough to have one reasonable hypothesis, and two at a time may be exceedingly rare. In Darwin's case, when he is forced to give up one hypothesis, he does not necessarily substitute another – he sometimes simply remains at a loss until his point of view matures sufficiently to permit the expression of a new hypothesis. (p. 146)
- Indeed, many great psychologists have made it explicit that they fail to follow the rules of the abstract methodologists. B. F. Skinner (1959), for one, confessed:
  The notes, data, and publications which I have examined do not show that I ever behaved in the manner of Man Thinking as described by John Stuart Mill or John Dewey or as in reconstructions of scientific behavior by other philosophers of science. I never faced a problem which was more than the eternal problem of finding order. I never attacked a problem by constructing a Hypothesis. I never deduced Theorems or submitted them to Experimental Check. So far as I can see, I had no preconceived Model of behavior – certainly not a physiological or mentalistic one, and I believe, not a conceptual one. … Of course, I was working on a basic Assumption – that there was order in behavior if I could only discover it – but such an assumption is not to be confused with the hypotheses of deductive theory. It is also true that I exercised a certain Selection of Facts, but not because of relevance to theory but because one fact was more orderly than another. If I engaged in Experimental Design at all, it was simply to complete or extend some evidence of order already observed. (p. 369)

We must delve more deeply into what great psychologists have had to say about the discovery process.

- These introspective reports should instruct us on how much more complicated our psychological models must become before they can provide a comprehensive account of the mental processes behind great science.
- In addition, some of these complications will later prove useful in helping us appreciate the personality characteristics that are associated with being a great psychologist.
- So, below I examine the role of trial and error, free association, imagery, intuition, incubation, serendipity, and inspiration.

Trial and Error

Helmholtz Helmholtz (1891/1898):

> I only succeeded in solving such problems after many devious ways, by the gradually increasing generalisation of favourable examples, and by a series of fortunate guesses. I had to compare myself with an Alpine climber, who, not knowing the way, ascends slowly and with toil, and is often compelled to retrace his steps because his progress is stopped; sometimes by reasoning, and sometimes by accident, he hits upon traces of a fresh path, which again leads him a little further; and finally, when he has reached the goal, he finds to his annoyance a royal road on which he might have ridden up if he had been clever enough to find the right starting-point at the outset. In my memoirs I have, of course, not given the reader an account of my wanderings, but I have described the beaten path on which he can now reach the summit without trouble. (p. 282)

Neal Miller:

> Published reports of research are written with the wisdom of hindsight. They leave out the initial groping and fumbling to save journal space (and perhaps also to save face) and exclude almost all of those attempts that are abandoned as failures. Therefore, they present a misleading picture which is far too orderly and simple of the actual process of trying to extend the frontiers of science into unknown territory. (quoted in Cohen, 1977, p. 243)

William S. Jevons (1877/1900):

> it would be an error to suppose that the great discoverer seizes at once upon the truth, or has any unerring method of divining it. In all probability the errors of the great mind exceed in number those of the less vigorous one. Fertility of imagination and abundance of guesses at truth are among the first requisites of discovery; but the erroneous guesses must be many times as numerous as those that prove well founded. The weakest analogies, the most whimsical notions, the most apparently absurd theories, may pass through the teeming brain, and no record remain of more than the hundredth part. … The truest theories involve suppositions which are inconceivable, and no limit can really be placed to the freedom of hypotheses. (p. 577)

Free Association

William James (1880):

> Instead of thoughts of concrete things patiently following one another in a beaten track of habitual suggestion, we have the most abrupt cross-cuts and transitions from one idea to another, the most rarefied abstractions and discriminations, the most unheard of combination of elements, the subtlest associations of analogy; in a word, we seem suddenly introduced into a seething cauldron of ideas, where everything is fizzling and bobbling about in a state of bewildering activity, where partnerships can be joined or loosened in an instant, treadmill routine is unknown, and the unexpected seems only law. (p. 456)

Ernst Mach (1896):

> more is required for the development of *inventions*. More extensive chains of images are necessary here, the excitation by mutual contact of widely different trains of ideas, a more powerful, more manifold, and richer connection of the contents of memory, a more powerful and impressionable psychical life, heightened by use. (p. 167)
>
> from the teeming, swelling host of fancies which a free and high-flown imagination calls forth, suddenly that particular form arises to the light which harmonises perfectly with the ruling idea, mood, or design. Then it is that that which has resulted slowly as the result of a gradual selection, appears as if it were the outcome of a deliberate act of creation. (p. 174)

Freud (1900/1952) quotes Schiller:

> The reason for your complaint lies, it seems to me, in the constraint which your intellect imposes on your imagination. … Apparently it is not good – and indeed it hinders the creative work of the mind – if the intellect examines too closely the ideas already pouring in, as it were, at the gates. Regarded in isolation, an idea may be quite insignificant, and venturesome in the extreme, but it may acquire importance from an idea which follows it; perhaps, in a certain collocation with other ideas, which may seem equally absurd, it may be capable of furnishing a very serviceable link. The intellect cannot judge all these ideas unless it can retain them until it has considered them in connection with these other ideas. In the case of a creative mind, it seems to me, the intellect has withdrawn its watchers from the gates, and the ideas rush in pell-mell, and only then does it review and inspect the multitude. (p. 181)

Harrison Gough (1976) showed that the ability to produce unusual associations is positively correlated with scientific creativity.

Especially interesting is the striking tendency for Nobel laureates in the sciences to give provide words that are opposites, antonyms rather than synonyms (Rothenberg, 1983).

Compatible results have been found using different instruments. For instance, a study of 40 eminent scientists (including 4 Nobel laureates) indicated that those who most consistently produced high-impact papers tended to be those who generated the highest number of responses to the inkblots of the Rorschach Test (Root-Bernstein, Bernstein, & Garnier, 1993).

Imagery

Max Wertheimer's (1945/1982) *Productive Thought*. E.g. Einstein's

> What if one were to run after a ray of light? What if one were riding on a beam? If one were to run after a ray of light as it travels, would its velocity thereby be decreased? If one were to run fast enough, would it no longer move at all? (Wertheimer, 1945/1982, p. 169)

These questions were only resolved by Einstein called "combinatory play" with "visual and motor" images "before there is any connection with logical construction in words or other kinds of signs which can be communicated to others" (quoted in Hadamard, 1945, p. 142). "The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought," said Einstein, "conventional words or other signs have to be sought for laboriously only in a secondary stage, when the mentioned associative play is sufficiently established and can be reproduced at will" (quoted in Hadamard, 1945, p. 143).

Galton, who pioneered the study of visual imagery as well as word associations, reported a similar two-step process:

> It is a serious drawback to me in writing, and still more in explaining myself, that I do not so easily think in words as otherwise. It often happens that after being hard at work, and having arrived at results that are perfectly clear and satisfactory to myself, when I try to express them in language I feel that I must begin by putting myself upon quite another intellectual plane. I have to translate my thoughts into a language that does not run very evenly with them. I therefore waste a vast deal of time in seeking for appropriate words and phrases, and am conscious, when required to speak on a sudden, of being often very obscure through mere verbal maladroitness, and not through want of clearness of perception. That is one of the small annoyances of my life. (quoted in Hadamard, 1945, p. 69)

Sometimes the images that rushed through Galton's head would be auditory rather than visual, but instead of sensible verbal ideas the images would sound "as the notes of a song might accompany thought" (quoted in Hadamard, 1945, p. 69).

Nobel laureate Otto Loewi: "If carefully considered in the daytime, I would undoubtedly have rejected the kind of experiment I performed. … It was good fortune that at the moment of the hunch I did not think but acted immediately" (Loewi, 1960, p. 18).

William James (1902) reported in his *Varieties of Religious Experience*,

> nitrous oxide and ether, especially nitrous oxide, when sufficiently diluted with air, stimulate the mystical consciousness in an extraordinary degree. Depth upon depth of truth seems revealed to the inhaler. This truth fades out, however, or escapes, at the moment of coming to; and if any words remain over in which it seemed to cloth itself, they prove to be the veriest nonsense. (p. 387)

Incubation

"imageless thought" (Roe, 1953b). "I just seem to vegetate; something is going on, I don't know what it is," reported one eminent scientist (Roe, 1953b, p. 144).

Autobiography of Herbert Spencer (1904):

> it has never been my way to set before myself a problem and puzzle out an answer. The conclusions at which I have from time to time arrived, have not been arrived at as solutions of questions raised; but have been arrived at unawares – each as the ultimate outcome of a body of thoughts which slowly grew from a germ. Some direct observation, or some fact met with in reading, would dwell with me: apparently because I had a sense of its significance. It was not that there arose a distinct consciousness of its general meaning; but rather that there was a kind of instinctive interest in those facts which have general meanings. … When accumulation of instances had given body to a generalization, reflexion would induce the vague conception at first framed to a more definite conception; and perhaps difficulties or anomalies passed over for a while, but eventually forcing themselves on attention, might cause a needful qualification and a truer shaping of the thought. … And thus, little by little, in obtrusive ways, without conscious intention or appreciable effort, there would grow up a coherent and organized theory. (pp. 463-464)

Spencer (1904) went on to say that conscious, deliberate mental process should actually prove counter-productive.

> The determined effort causes perversion of thought. When endeavouring to recollect some name or thing which had been forgotten, it frequently happens that the name or thing sought will not arise in consciousness; but when attention is relaxed, the missing name or thing often suggests itself. While thought continues to be forced down certain wrong turnings which had originally been taken, the search is in vain; but with the cessation of strain the true association of ideas has an opportunity of asserting itself. And, similarly, it may be that while an effort to arrive forthwith at some answer to a problem, acts as a distorting factor in consciousness and causes error, a quiet contemplation of the problem from time to time, allows those proclivities of thought which have probably been caused unawares by experiences, to make themselves felt, and to guide the mind to the right conclusion. (pp. 464-465).

Helmholtz (1891/1971):

> As I have often found myself in the unpleasant position of having to wait for useful ideas, I have had some experience as to when an where they come to me which may perhaps be useful to others. They often steal into one's train of thought without their significance being at first understood; afterward some accidental circumstance shows how and under what conditions they originated. Sometimes they are present without our knowing whence they came. In other cases they occur suddenly, without effort, like an inspiration. As far as my experience goes, they never come to a tired brain or at the desk.
>
> I have always had to turn my problems about in my mind in all directions, so that I could see their turns and complications and think them through freely without writing them down. To reach that stage, however, was usually not possible without long preliminary work. Then, after the fatigue of the work had passed away, an hour of perfect bodily repose and quiet comfort was necessary before the fruitful ideas came. Often they came in the morning upon waking … But, … they were most apt to come when I was leisurely climbing about on wooded hills in sunny weather. The slightest quantity of alcohol seemed to frighten them away. (pp. 474-475)

This parallel processing means that the progression of ideas and facts in one project will often set off a train of associations in some seemingly unrelated project, priming solutions that might not appear otherwise.

"I can remember the very spot in the road, whilst in my carriage, when to my joy the solution occurred to me" (Darwin, 1892/1958, p. 43).

Serendipity

Walter Cannon's (1940) "The Role of Chance in Discovery," in which he provides many examples of serendipitous findings in the history of science (also see Austin, 1978; Shapiro, 1986). Among these cases is Luigi Galvini's discovery of animal electricity and Claude Bernard's discovery that blood circulation was under nervous control. Cannon also provided an illustration from the accidental observation that led to his concept of homeostasis:

> About forty-three years ago, shortly after the x-rays were discovered, I was using the mysteriously penetrating light to look into animals in order to watch the little known processes of digestion. The churning and mixing of the food was clearly visible. Occasionally, however, my purposes were wholly checked because the motions came to a dead stop. That was a great annoyance; it seemed very strange, and I was at a loss to account for it. But in scientific investigation, as in daily living, obstacles may yield important values. I soon noticed that the cessation of the digestive activities was associated with signs of anxiety or other emotional disturbance. Could it be that I was seeing the harmful effects of worry on the organs which serve to make the food useful to the body? That proved to be true, for when I petted the animals reassuringly the churning waves promptly started again, and when excitement was induced the waves promptly stopped. … It was the beginning of many years of research on bodily functions – research which ultimately led to insight into the agencies of our organism which maintain the stability of the extraordinarily unstable material of which we are composed and which give us freedom to live and carry on our various activities untrammeled by external heat or cold, by flight to high altitudes or by the internal changes produced by strenuous efforts in which we may engage. The observation of the effects of worry on digestion also resulted ultimately in a suggestive concept of the nature of emotional excitement, and, furthermore, in the demonstration of a chemical agent which acts as an intermediary between nerves and muscles when muscles are made to contract or relax. (p. 208).

Many lucky discoveries "were seen numbers of times before they were noticed," as Ernst Mach (1896, p. 167) put it.

Cannon (1940) stressed "the importance of avoiding rigid adherence to fixed ideas" (p. 208). And B. F. Skinner (1959) emphasized "a first principle not formally recognized by scientific methodologists: when you run onto something interesting, drop everything else and study it" (p. 363).

In addition, this flexibility and openness should be coupled with ample knowledge about the field. "If the psychical life is subjected to the incessant influences of a powerful and rich experience," said Mach (1896, p. 171), "then every representative element in the mind is connected with so many others that the actual and natural course of the thoughts is easily influenced and determined by insignificant circumstances, which accidentally are decisive."

Charles Darwin specified what he thought to be his best intellectual asset, he said "I think that I am superior to the common run of men in noticing things which easily escape attention" (quoted in Hyman, 1963, p. 373). This virtue was confirmed by Francis Darwin, his father's frequent scientific collaborator. Francis took special note of his father's

> instinct for arresting exceptions: it was as though he were charged with theorizing power ready to flow into any channel on the slightest disturbance, so that no fact, however small, could avoid releasing a stream of theory, and thus the fact became magnified into importance. In this way it naturally happened that many untenable theories occurred to him; but fortunately his richness of imagination was equalled by his power of judging and condemning the thoughts that occurred to him. He was just to his theories, and did not condemn them unheard; and so it happened that he was willing to test what would seem to most people not at all worth testing. These rather wild trials he called "fool's experiments," and enjoyed extremely. (Darwin, 1892/1958, p. 101)

Inspiration

Friedrich Nietzsche (1927) has written that

> one can hardly reject completely the idea that one is the mere incarnation, or mouthpiece, or medium of some almighty power. The notion of revelation describes the condition quite simply; by which I mean that something profoundly convulsive and disturbing suddenly becomes visible and audible with indescribable definiteness and exactness. One hears – one does not seek; one takes – one does not ask who gives: a thought flashes out like lightning, inevitably without hesitation – I have never had any choice about it. There is an ecstacy whose terrific tension is sometimes released by a flood of tears, during which one's progress varies from involuntary impetuosity to involuntary slowness. There is the feeling that one is utterly out of hand, with the most distinct consciousness of an infinitude of shuddering thrills that pass through from one head to foot; – there is a profound happiness in which the most painful and gloomy feelings are not discordant in effect, but are required as necessary colors in this overflow of light. There is an instinct for rhythmic relations which embraces an entire world of forms…. Everything occurs quite without volition, as if in an eruption of freedom, independence, power and divinity. The spontaneity of the images and similes is most remarkable; one loses all perception of what is imagery and simile; everything offers itself as the most immediate, exact, and simple means of expression. (pp. 896-897)

Nietzsche admitted that "this is *my* experience of inspiration" (p. 897) and that others may not have exactly the same phenomenological encounter.

INTERDISCIPLINARY CONTRASTS

Havelock Ellis' (1926) claim that "the characteristics of men of genius [are] probably to a large extent independent of the particular field their ability is shown in" (p. xv).

There is also ample anecdotal evidence that various intellectual aptitudes may be rather differently distributed even among the greatest minds.

Helmholtz (1891/1971) once confessed that

> a defect among my mental powers showed itself, however, almost early: I had a poor memory for unrelated facts. The first indication of this was, I believe, the difficulty I had in distinguishing between left and right. Later, when I began the study of languages at school, I had greater difficulty than others in learning vocabularies, irregular grammatical forms, and peculiar forms of expression. … This defect has, of course, grown and has been a vexation to me in my later years. (p. 468)

As observed earlier, Darwin suffered from a similar linguistic incapacity, and yet Helmholtz, unlike Darwin, was quite proficient in mathematics and physics.

Accordingly, below I will examine interdisciplinary differences in cognitive attributes of scientists. In particular, I will review how scientists from different domains might vary according to

- intelligence,
- imagery, and
- versatility.

This review should contribute to our understanding of how psychology fits in with other sciences.

Intelligence

Catharine Cox's (1926) volume in Terman's *Genetic Studies of Genius*.

Table 6.2 shows the mean estimated IQs that she calculated for scientists, philosophers, nonfiction authors, and religious leaders.

Cox's results have been replicated in a later historiometric investigation, which found the following mean IQs: philosophers 173, scientists 164, nonfiction authors 162, religious leaders 159, and artists 150 (Walberg, Rasher, & Hase, 1978).

In neither study was there found a group whose IQ means exceeded those found in the two domains most intimately linked to psychology, philosophy and science.

Psychometric studies of contemporary samples.

Anne Roe's (1953a) *The Making of a Scientist*;

- studied 64 eminent American scientists: 22 physicists, subdivided into experimentalists and theoreticians; 20 biologists; and 22 social scientists, namely 8 anthropologists and 14 psychologists.
- she made up some special tests with the help of the Educational Testing Service: verbal, spatial, and mathematical.
- Table 6.3 shows the resulting IQs (converted from the raw scores that Roe provided).

Table 6.3

Psychometric IQs: Means and Ranges for 64 Eminent American Scientists

	Verbal		Spatial		Mathematical	
Achievement domain	***M***	**Range**	***M***	**Range**	***M***	**Range**
Psychologists	**163**	**133-176**	**141**	**127-161**	**162**	**139-194**
Anthropologists	**165**	**150-175**	**135**	**123-151**	**142**	**128-154**
Biologists	**162**	**138-176**	**137**	**123-164**	**165**	**133-194**
Experimental physicists	**154**	**121-174**	**141**	**123-161**	–	–
Theoretical physicists	**168**	**158-177**	**149**	**149-161**	–	–

***Note*. The standardized means and ranges were converted from the raw scores given in Roe (1952).**

Another investigation that actually administered the WAIS to scientists hailing from distinct disciplines (Gibson & Light, 1967).

- Although these scientists were not singled out for their eminence, they did hold appointments at a highly eminent university, Cambridge, and accordingly can be considered more than run-of-the-mill.
- The social scientists in the sample had mean IQs of 122, which matches that for the agricultural sciences but which is otherwise lower than was found for the mathematicians, biochemists, and chemists (all 130), the physicists (128), the medical scientists (127), and the biologists (126).
- Nonetheless, the ranges were again large, including 112-132 for the social scientists, 112-136 for the physicists, 113-135 for the biological scientists, 116-134 for the medical scientists, and 124-136 for the mathematicians. The distributions overlap considerably.

Although Roe (1953a) did not provide much in the way of details, she did separate out the experimental psychologists from the rest of the distinguished psychologists in her sample. Roe found that they scored higher in spatial and mathematical intelligence, but lower than verbal intelligence, in comparison to their disciplinary colleagues.

This contrast parallels what was found for the physicists, the theorists being more verbal and the experimentalists more spatial.

Hence, there is some tentative evidence that the IQ profile corresponds to the subdiscipline in which a psychologist is most likely to achieve distinction.

Imagery

Roe's (1953a) study of 64 eminent scientists actually found differences.

- She specifically asked them to report what mental processes they are most likely to use when coming up with their creative ideas.
- Scientists in all disciplines reported some amount of visual imagery, but eminent social scientists differed conspicuously from the other scientists in its specific nature.
- For the biologists and physicists, visual imagery could take the form of concrete, often 3-dimensional images, geometrical and other types of diagrams, and visualized symbols,
- whereas for the social scientists, such thoughts were confined to concrete images rather than abstract diagrams or symbols.
- Moreover, only 14% of the social scientists reported such concrete imagery, in contrast to 27% of the theoretical physicists, 55% of the biologists, and 78% of the experimental physicists.
- On the other hand, it is evident that the social scientists depended much more heavily on auditory and verbal imagery. More than half (52%) reported that they verbalize their thinking, whereas such verbal imagery was experienced was experienced by only 36% of the theoretical physicists, 30% of the biologists, and none of the experimental physicists.
- The physicists, however, were more likely to verbalize mathematical formula – 11% of the experimentalists and 27% of the theoreticians – something neither the biologists (0%) nor the social scientists (5%) were much inclined to do, if at all.
- The more prominent verbal imagery of the social scientists was also revealed in their responses to the Thematic Apperception Test:
- They tended to tell much longer stories, indicative of greater verbal fluency. Although the social scientists appear to be mostly verbalizers, there are two interesting twists.
    - First, 19% of the social scientists reported kinesthetic imagery, an experience claimed by none of the other groups.
    - Second, 72% reported imageless thought, relative to 67% of the experimental physicists, 55% of the theoretical physicists, and 35% of the biologists.

It would worth knowing whether the type of imagery influences to particular school of thought a psychologist is most likely to subscribe. Intuitively, for example, psychoanalysts appear to be disposed toward verbalizations, Gestalt psychologists toward visualizations, and Hullian behaviorists to mathematical and symbolic representations.

Versatility

- Cox's (1926) 301 geniuses had exceptional intellectual versatility.
    - Leonardo da Vinci was a painter, sculptor, engineer, musician, and scientist,
    - Pascal a mathematician, physicist, inventor, philosopher, and essayist, and Goethe a poet, novelist, dramatist, botanist, and government official.
- A secondary analysis indicated that most of her creators and leaders exhibited above-average attainments in 5 to 10 achievement domains (R. K. White, 1931).
    - The highest level of versatility was displayed by the nonfiction writers, leaders, and philosophers, followed by the scientists, mathematicians, religious leaders, and fiction writers.
    - Soldiers, artists, and especially musicians were by far the least versatile.
    - Furthermore, certain types of achievement tended to cluster together. One such cluster consisted of science, mathematics, medicine, invention, and, to a lesser extent, art.
- According to a study of more than 1,000 20th-century notables, "10% showed competency or proficiency in three or more separate fields (or two or more different media within at least one of two fields); 28% in two separate fields; 43% in two or more related media of expression within a particular field; and 19% in only one medium or none at all" (Ludwig, 1995, p. 112).
- A survey of eminent scholars found that more than two thirds kept up with research in at least one field outside their own, where "keeping up" often meant publishing in that field as well (R. J. Simon, 1974). Philosophers boasted the widest range of active interests – statistics, physics, biology, psychology, and literature among them.
- More important, the degree of versatility is positively associated with the degree of distinction achieved.
    - This positive correlation was first demonstrated for 120 scientists and 123 writers a decade after Cox's study (Raskin, 1936),
    - and was later confirmed in a secondary analysis of the Cox's 301 geniuses a half century after her pioneering investigation (Simonton, 1976a).
    - The correlation between versatility and eminence – the latter again based on James McKeen Cattell's (1903c) rankings – was .23.
    - In addition, versatility correlated around .30 with Cox's IQ estimates, suggesting that versatility is a sign of the influx of Spearman's *g*.
- Comparable results are found using entirely different data sets.
    - For instance, one survey found that the most influential social scientists are prone to express more interests in disciplines besides their own (Manis, 1951).
    - Also, according to a historiometric study, the most eminent thinkers of Western civilization tended to make a name for themselves in multiple philosophical specialties (Simonton, 1976f). A lesser thinker might rest satisfied by making a contribution to just epistemology, ontology, psychology, aesthetics, ethics, *or* social philosophy, but a truly great thinker will address virtually every major philosophical question that has dominated the history of ideas.
- Actually, the functional relation between versatility and greatness might be a bit more complex. According to a recent historiometric study of more than 2,250 scientists, a U-shaped function is superimposed over the positive linear relation, creating a J-curve between eminence and the number of fields in which important contributions were made (Sulloway, 1996). That is, the most famous are those who are extremely versatile, followed by those who were extremely specialized. Those who dabbled in just a couple of scientific domains attained the least renown.