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Editorial

Why are modern scientists so dull? How science selects for perseverance and sociability at the expense of intelligence and creativity

SUMMARY

Question: why are so many leading modern scientists so dull and lacking in scientific ambition? *Answer:* because the science selection process ruthlessly weeds-out interesting and imaginative people. At each level in education, training and career progression there is a tendency to exclude smart and creative people by preferring Conscientious and Agreeable people. The progressive lengthening of scientific training and the reduced independence of career scientists have tended to deter vocational 'revolutionary' scientists in favour of industrious and socially adept individuals better suited to incremental 'normal' science. High general intelligence (IQ) is required for revolutionary science. But educational attainment depends on a combination of intelligence and the personality trait of Conscientiousness; and these attributes do not correlate closely. Therefore elite scientific institutions seeking potential revolutionary scientists need to use IQ tests as well as examination results to pick-out high IQ 'under-achievers'. As well as high IQ, revolutionary science requires high creativity. Creativity is probably associated with moderately high levels of Eysenck's personality trait of 'Psychoticism'. Psychoticism combines qualities such as selfishness, independence from group norms, impulsivity and sensation-seeking; with a style of cognition that involves fluent, associative and rapid production of many ideas. But modern science selects for high Conscientiousness and high Agreeableness; therefore it enforces low Psychoticism and low creativity. Yet my counter-proposal to select elite revolutionary scientists on the basis of high IQ and moderately high Psychoticism may sound like a recipe for disaster, since resembles a formula for choosing gifted charlatans and confidence tricksters. A further vital ingredient is therefore necessary: devotion to the transcendental value of Truth. Elite revolutionary science should therefore be a place that welcomes brilliant, impulsive, inspired, antisocial oddballs – so long as they are also dedicated truth-seekers.

Introduction

Why are so many leading modern scientists intellectually dull and lacking in scientific ambition? The short answer is: because the science selection process ruthlessly weeds-out interesting and imaginative people [1].

At each level in education, training and career progression there is a tendency to exclude smart and creative people by preferring conscientious and sociable people. As science becomes ever-more dominated by 'peer review' mechanisms, pro-social behaviour in scientists has been accorded primacy over the brilliant and inspired – but abrasive and rebellious – type of truth-seekers who used to be common among the best scientists.

A majority of senior professional scientists have been through a rigorous and prolonged process of education, selection and training to become professional researchers. Yet the nature of the rigour and the duration of the process in modern science ensures that those who come out at the end and attain long-term scientific employment are not the kind of people capable of top level, revolutionary science. They will very probably be extremely productive and socially compliant, but of only moderately high intelligence and likely to be lacking in imagination [2].

(Of course, such an accusation of dullness is less likely to fit those scientists who are reading this article than the average scientist, since it is generally acknowledged that people who read or publish in Medical Hypotheses are atypical and tend to come from the more vividly colourful end of the scientific spectrum!)

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Dullness-inducing trends in modern science

Modern science is just too dull an activity to attract, retain or promote many of the most intelligent and creative people. In particular the requirement for around 10, 15, even 20 years of postgraduate 'training' before even having a chance at doing some independent research of one's own choosing, is enough to deter almost anyone with a spark of vitality or self-respect; and utterly exclude anyone with an urgent sense of vocation for creative endeavour. Even after a decade or two of 'training' the most likely scientific prospect is that of researching a topic determined by the availability of funding rather than scientific importance, or else functioning as a cog in someone else's research machine. Either way, the scientist will be working on somebody else's problem – not his own. Why would any serious intellectual wish to aim for such a career?

The whole process and texture of doing science has slowed-up. Read the memoirs of scientists active up to the middle 1960s – doing science then was nimble and fast-moving in texture and also longer-termist in ambition. Unexpected leads could be pursued. It was common for people to begin independent (really independent) research in their early- to mid-twenties. For the individuals concerned there was a palpable sense of progress, a crackling excitement.

Nowadays, training to be a scientist is an exercise in almost-endlessly-deferred satisfaction. There is an always-increasing requirement for years of training (i.e., extra years of doing what

other people decide you 'need' to do, and not what interests you) – and also for more advance-planning, application for committee permissions, and demand for logistical organization; combined with a proliferation of scientifically-irrelevant and energy-sapping bureaucracy.

The timescale of scientific action and discourse has gone up from days, weeks and months to months, years and decades. Yet at the same time, the requirement for unremitting annual high productivity means that the timescale for research pay-off has contracted to a maximum of 3–5 years. It is usually career suicide to take the time and risks entailed by scientifically-ambitious research [2]. In sum, the tempo of science has slowed but the time-horizon of science has contracted. Modern science is both duller and more short-termist: the worst of both worlds!

Demanding superhuman perseverance filters-out intelligence and creativity

The kind of person who can thrive in the world of modern science is likely to be characterized primarily by an almost superhuman level of the personality attribute of perseverance – the ability doggedly to continue a course of action in pursuit of a goal, over a long period and despite difficulties, setbacks and the lack of immediate rewards (and indeed the lack of any guaranteed ultimate rewards); with simultaneous, continuous productivity.

Modern science therefore imposes an extraordinarily high minimum threshold for perseverance – lacking which will deter many individuals from going into science in the first place, and which will cull and exclude many others during the process of accumulating sufficient qualifications and experience to allow them to embark on independent research. Other near-synonyms for perseverance are 'self-discipline' or 'grit' [3–5] and the 'Big Five' personality trait called 'Conscientiousness' (abbreviated here as 'C') [6].

Secondarily such an individual will usually need to have high levels of the Big Five personality trait termed 'Agreeableness' (abbreviated here as 'A') – which encompasses the ability to empathize with others, get along with groups, and compliantly to put the interests of the group above one's own concerns [6].

Now, both Conscientiousness and Agreeableness are admirable traits in terms of society as a whole. Most people would wish to live in a society where Conscientious and Agreeable people predominated. Furthermore, a higher level of Conscientiousness, in particular, is predictive of better job performance [7]. But, success in top level revolutionary science demands somewhat different qualities than society as a whole. While high levels of Conscientiousness and Agreeableness make a person an excellent citizen and employee; high average levels of these traits in selected personnel are attainable only at the cost of accepting lower average levels of other attributes (such as IQ and creativity).

This is a serious problem because Conscientiousness and Agreeableness are not the most important traits required for doing 'revolutionary' science at the highest level [9,10]. (Revolutionary science is that type of science which changes the direction of science [9]; a revolutionary scientist is one whose activates are directed at this goal, someone trying to develop qualitatively new theories or methods [10].) Instead, for success in revolutionary science intelligence and creativity are the most important qualities [8]. Further, there is evidence to suggest that very high levels of the traits of Conscientiousness and Agreeableness may actually be hostile to – or even incompatible with – scientific genius; because to be hard-working and pleasant is useful only when these virtues are mobilized in pursuit of worthwhile scientific goals – and not when they become the highest scientific value in their own right.

The vital importance of high IQ in revolutionary science

The personnel requirements for being a good science employee on the one hand and on the other hand an original and ambitious 'revolutionary' scientist are, in some respects, in opposition. This should not really be surprising – but the implications have been ignored and flouted for several decades.

For an employee in 'normal' science – that is, science which aims at incrementally building on existing ideas and knowledge – reliability and technical competence are primary [9,10]. The great bulk of modern science is 'normal' science – that has been the major focus of expansion in funding and manpower over the past 60 years [11,12]. Such scientists do not need to be original; rather they need to be hard-working, meticulous and conservative in terms of their ideas and methods. And since normal science is increasingly collaborative, it is beneficial if normal scientists enjoy working socially and within group norms. High intelligence is also valuable in normal science, as it is in almost all employment activities [13], but perhaps especially valuable in the 'troubleshooting' aspects of normal science – making methods work.

So, for normal science it seems that high Conscientiousness is essential, high intelligence and Agreeableness are both useful, but creativity is probably detrimental.

But for revolutionary science intelligence and creativity are both vital ingredients. By contrast, Conscientiousness is necessary in revolutionary science only to the degree that a scientist must be able and willing to work long and hard at his chosen scientific problem, the problem which fascinates him. And working on your own problem requires much less perseverance than working hard for many years at non-scientific problems (as happens at school or during the first college degree), or working hard for many years at other peoples' scientific problems (as required at graduate school or when working as a post-doc).

General intelligence (or 'g factor' intelligence), as measured by formal IQ tests, is a very important psychological ingredient in the ability to perform top level scientific research [8]. Indeed, to understand both the nature of g factor intelligence and the nature of elite science is to recognize as obvious the value of high general intelligence to research in revolutionary science [14]. Studies of the best scientists suggest that these typically have very high IQ of several standard deviations above average [8]. (Note: for the UK the average IQ of a random population sample is defined as 100 with a standard deviation defined as 15 points – other nations may have a different average/ distribution when calibrated against UK IQ norms.)

Cox's study of 1926 retrospectively and indirectly estimated the average IQ of 'genius' scientists from the past as between 135 and 175, which is in the top 1% of the population (cited in [8]) – however the methodology generated only imprecise measurements During the 1950s Roe performed direct IQ tests on 23 highly-eminent US scientists [15] and found a median verbal IQ of 166 with a range from 121 to 177 (177 is about 5 standard deviations above average and was the ceiling of the tests; otherwise some subjects would have scored even higher).

Since very high IQ is found to be a near-universal feature of top scientists, it is presumably a necessary factor in becoming a top scientist. One way of looking at this is that successful revolutionary scientists are apparently among the most intelligent humans alive. And Roe's work suggests that the minimum IQ for successful revolutionary science may be about 120 – which is in the top 10% of the UK population; or about the top 7% of the US population which has a slightly lower average IQ than the UK; or about 15% of the population of some East Asian countries such as Taiwan, Singapore or Hong Kong, which have a higher average IQ than the UK [16].

Furthermore, prospective follow-up cohort studies of 'gifted' children (i.e., children with very high formally-measured IQs [17,18]) have demonstrated much higher than average ability in science examinations, with greatly increased rates of achieving the highest levels of educational attainment (e.g., pure science, medical or engineering doctorates at elite universities); also a strong tendency to study science subjects as a career (e.g., mathematics, pure sciences, engineering and medicine) at both Bachelors and Doctoral level; and much higher than average attainment of measures of elite scientific performance such as election to major scholarly societies. However, it is important to recognize that most of these measures do not differentiate between normal science and revolutionary science.

In sum, achievement in revolutionary science almost certainly requires a very high IQ; and a high IQ was in the past often associated with a career choice towards, and aptitude in, scientific subjects. However, nowadays it is seldom that direct IQ measurements are explicitly used as a selection method in modern science; and instead examination performance or other educational measures are usually given the greatest weighting. Hence we simply do not know the size of effect of modern selection, education, training and career structure on the average and peak IQ of scientists who stay the course to become long-term researchers.

But although the size of effect is not known, and making the assumption that the intellectual quality of scientific recruits has not risen significantly and the size of the population of professional scientists has not fallen to make a more selected elite (in fact science employment has grown several-fold), then the effect of modern scientific selection practices is very probably in the direction of reducing average IQ among long-term researchers.

Intelligence and Conscientiousness predict educational attainment

It has been known for more than a century that many types of attainment, including educational qualifications such as examination results, are predicted by a combination of 'capacity' or 'ability' with 'zeal' or 'motivation' (summarized in [19]). In more modern terms, this implies that general (g factor) intelligence (IQ) and Big Five Conscientiousness (*C*) are the main contributors to educational attainment.

The relationship between IQ and *C* can be expressed as an equation

$$IQ \times C \approx \text{Educational attainment}$$

(Note that because the relationship between IQ and *C* is multiplicative, this equation correctly implies that 'zero' (or very low) levels of either IQ or *C* would prevent significant educational attainment.)

The above equation derives from Lynn [19], who actually proposed the more general formulation of "IQ × Conscientiousness × opportunity = Achievement". However, I have left-out the multiplication by opportunity, as this is hard to evaluate, and (within the normal bounds of developed societies) there is little evidence that variations in opportunity create significant systematic differences in achievement when IQ (and perhaps personality) are controlled [14,20].

Therefore, at a first approximation, the best established personal attributes that predict educational attainment are IQ [13,14,21] and *C* [3,22–25]. Intelligence and Conscientiousness are certainly not the only factors contributing to educational attainment, but they are probably the most important and – since other factors are less certain or harder to measure – I will focus exclusively on IQ and *C*.

The measured level of correlations between IQ, *C* and educational attainment depend on the population studied, the subject and nature of the educational measurement, and the methodology. Traditionally IQ has been more powerful at predicting educational performance than personality [13,14,21,22], but not always [3]; and my guess is that over recent decades the predictive ability of IQ will very likely have declined, and that of *C* increased, due to increased demands for *C* in the educational process.

IQ and C are not highly correlated – so selection for Conscientiousness tends to depress average IQ

At an individual level there is little or no observable correlation between intelligence and Conscientiousness. Some group studies – especially sampling across very diverse social classes, ethnic groups or nations – show a positive correlation between IQ and measures correlated with *C* [16,19,26], many studies show no significant correlation [5,27], and other studies show a significant negative correlation between IQ and *C* [28].

Probably the reason for this observed discrepancy between studies relates to subject selection. My guess is that when a population sample is very diverse in terms of educational attainment, class or ethnicity there will be a positive correlation between IQ and *C*; but when the sample is controlled for class or educational attainment (as in university student samples) the correlation may disappear or become inverse because the same level of educational attainment can be the result of various combinations of IQ and *C*. For example, a harder working person with lower IQ may get the same examination results as a higher IQ person who works less hard.

In other words; when educational attainment is held constant by sampling only a narrow stratum of educational attainment then there may be an inverse relationship between IQ and *C*, as indicated by a reversed version of the above equation: Educational attainment $\approx IQ \times C$.

But the lack of a strong correlation between IQ and Conscientiousness means that when very high levels of perseverance are a pre-requisite for scientists (i.e., only people who have competed a PhD and 6 years of postdoctoral research are eligible for selection) then this increased average level of *C* will inevitably be attainable only at the cost of sacrificing other personal abilities including IQ. This effect would be more powerful where educational attainment is held constant and IQ and *C* have a reciprocal relationship – but selecting for *C* would tend to depress average IQ even when there is no significant relationship between the variables.

For instance, imagine a university was selecting the top 10% of applicants for a PhD program. The average accepted person might be in the top 10% for IQ and also the top 10% for *C* – and around this average some would be harder working but less bright and others would be brighter but less diligent. (Students who were higher than the top 10% in both IQ and *C* would probably attend a higher ranked and more selective university.)

Now suppose that there was an increased level of Conscientiousness required to reach a given level of educational attainment – for example there was a shift from infrequent formal exams to frequent coursework, plus an extra 3 years were added to the formal educational process. The imaginary university would still have the same degree of selectivity (i.e., taking the top 10% of students) and would still be taking the top 10% on the basis of exam attainment – but now students would need to be in the top 5% for *C*.

With a requirement for *C* in the top 5%, many of the top 10% IQ students who had previously been eligible would no longer be able (or willing) to complete their educational evaluations; and their places would be taken by students of lower IQ but in the top 5% of *C*. The university might need to dredge down to include (say) the top 20% for IQ. Average IQ of successful applicants would reduce, and the newly-excluded high IQ but lower *C* students would

then drop down the system to attend universities with a lower degree of selectivity (and they would thereby probably lose some of their competitive career edge).

When requirements for perseverance are increased, throughout the educational system there would be an assortment process such that higher *C* people will move up the system to more selective institutions and lower *C* individuals will move down the system. Students with the very best examination results would still have both very high IQ and very high *C* – but there would not be many such students since there is no strong positive correlation between IQ and *C*. In essence, students with higher *C* would now be valued more than those with higher IQ.

Typically, and all else being equal, greater selectivity for *C* therefore entails lesser selectivity for IQ.

A long-lasting, step-wise, hierarchical and competitive educational system tends to filter-out high IQ

Intelligence becomes progressively more powerful at predicting educational and occupational success as the cognitive demands of the job increase. IQ probably becomes more important the more advanced the educational level, and the higher the level of scientific activity. Conversely, it would be expected that non-IQ factors, especially *C*, will be more important at lower levels of scientific education, training and professional practice. So, a level of intelligence which suffices for excellence in routine, technical science could be grossly inadequate for cutting edge, revolutionary science.

The implication is that there is an intrinsic tendency for lower levels of the educational system, including scientific education, to select for different personal qualities than are required at higher levels. The tendency is for lower levels to favour higher Conscientiousness candidates at the expense of higher IQ candidates. Because at early stages of science perseverance is relatively more valuable than it is at advanced levels of science, and IQ is less valuable (since the cognitive demands are easier).

In the absence of specific IQ testing (used to identify and retain or promote the most intelligent candidates); a long-lasting, step-wise, hierarchical and competitive educational system – in which progression to more advanced stages depends on differentially successful performance at easier and less cognitively-demanding stages – will favour the most Conscientious individuals and select-out some individuals whose higher IQ would be expected to generate higher performance at advanced levels of the profession.

The result is that the highest levels of science almost certainly have a lower average IQ than would be optimal – due to the cohort having been selected so strongly for a higher level of *C* at lower (less cognitively-demanding) levels of the hierarchy. Since very high IQ is likely to be necessary for successful revolutionary science, the implication is that too many high level scientists are prevented (by their too-low IQ) from operating as revolutionary scientists. Instead they (presumably) become normal scientists – but unusually productive normal scientists (due to their vast capacity for hard work and self-discipline).

Of course, the loss of high IQ individuals could be compensated by the selective sieve causing a reduction in the number of people retained as the ladder is ascended – so that even if half of the high IQ people were lost, then this might not be noticed if only a quarter of people were retained. However, the long-term expansion of science funding with several-fold increase in the numbers of professional scientific personnel over recent decades [2,12] means that this kind of increasingly selectivity is unlikely to be operative.

In essence, high level scientific personnel should be a 'highest IQ elite' most of whom are capable of revolutionary science; but in modern science the leadership is more like a 'highest perseverance elite' who are typically incapable of revolutionary science and instead do a great deal of normal science [2].

Combining examination results with IQ testing can indirectly estimate Conscientiousness

A vital step should be to do a lot more IQ testing throughout science. IQ tests are powerfully predictive in many ways [29], including being highly predictive of job performance (in all jobs, but especially cognitively-complex jobs) [13] and there are many reasons why IQ testing should be much more widely deployed in our society. However, widespread (and deliberate) politically-motivated misrepresentation and disinformation currently prevents this situation [30].

Intelligence testing is particularly valuable in science because the ability to understand science and do scientific research is highly dependent on IQ. And formal IQ testing has probably become more necessary over recent decades as the educational system has evolved to be more selective for Conscientiousness (hence less selective for IQ). For example, in the UK and the USA educational systems there have been greatly increased demands for course work instead of less-frequent formal, supervised and timed examinations; as well as the above-mentioned lengthening duration of education and training.

The point of measuring IQ in a candidate would be to look for discrepancies between IQ testing and examination performance. If there is a large difference in ranked performance in examinations and IQ tests this will imply that the subject's Conscientiousness is unusually high or low.

This can be expressed in the form of a rearranged equation relating IQ and *C*

$$\text{Conscientiousness} \approx \frac{\text{Educational attainment}}{\text{IQ}}$$

or expressed in terms of rank orderings:

$$\text{Ranking for } C \approx \frac{\text{Ranking for Educational attainment}}{\text{Ranking for IQ}}$$

In other words, measures of educational attainment and intelligence can, together, be used as an indirect estimate of Conscientiousness.

(It seems to me that in the context of institutional selection and career decisions this indirect method of estimating Conscientiousness is likely to be more valid than the usual method of self-rating personality questionnaires [6] because it is much harder to cheat. It is facile for high IQ people to cheat in self-rating questionnaires by learning the correct responses that are marked to indicate high (or low) conscientiousness. But the only way for applicants to 'fake' this indirect method of estimating *C* would be to perform deliberately badly on either the IQ test or the examination – which would usually be a career-damaging strategy. For example, a candidate who dishonestly wished to signal high *C* could do so by deliberately performing badly on their IQ test, so that their exam ranking was higher than their IQ ranking. But there are not many selection or employment situations when this would be an adaptive strategy. Conversely, a person could make themselves look like an 'underachiever' by deliberately messing up their exams but trying hard on the IQ test – so their IQ rank was higher than their exam rank – however this would only be achievable at the cost of lowering their exam results, which is not often going to be a helpful thing to do.)

The object of this exercise in comparing exam results with IQ tests is to enable revolutionary science educational or research institutions to select under-achievers in preference to over-achievers. If, for example, a person is in the top 2% of the population for IQ but the exam results are only in the top 20%, then it is plausible that the relatively weak exam performance happened because the subject is relatively lower in *C* (although still above average). This is under-achievement.

If population norms are not available, then an institution could simply place its candidates into relative order for their examination results compared with their performance in an IQ test. Any significant discrepancies in rank ordering between the two lists would suggest either over- or under-achieving. For example, an under-achiever might be ranked second out of 20 for IQ and 16 out of 20 for exam results.

The opposite situation – 'over-performers' – are those who have significantly higher ranked exam results than IQ test results. The interpretation is that over-performers are higher in C lower and lower in IQ (harder working but less intelligent).

Agreeableness versus Psychoticism and creativity

High IQ is required for revolutionary science, but high IQ people are not necessarily creative – indeed some people with the highest recorded IQs have been (apparently) uncreative. And creativity as well as high IQ is required by revolutionary scientists – indeed revolutionary science is one of the primary arenas of human creativity with iconic figures such as Newton, Darwin and Einstein [8].

Perhaps surprisingly, creativity has often been found to be predicted by moderately high levels of Eysenck's personality trait of 'Psychoticism' [31]. The trait of Psychoticism has been well-validated [6,32]; high psychoticism combines low-Agreeableness (e.g., higher selfishness, independence from group norms), low Conscientiousness (for example impulsivity, sensation-seeking) with a style of cognition that involves fluent, associative and rapid production of many ideas. So, although a trait of low Psychoticism implies a rational and pro-social personality (which are usually highly desirable traits); moderately high Psychoticism is not merely antisocial but has positive aspects as well – since it has flavours of independence of spirit and a more spontaneous and fantasy-like mode of thinking. This style of cognition seems to be a basis for creativity.

The highest levels of Psychoticism are maladaptive (as the name implies) since the individuals' behaviour is so impulsive as to render impossible any sustained effort, so antisocial as to be psychopathic (and lead to prison or expulsion from society) and their thought processes are so disorganized as to be psychotic with hallucinations, delusions and thought-disorder (and lead to incoherence, un-employability and perhaps hospitalization). But Eysenck showed that a moderately high degree of the trait of Psychoticism is associated with creativity (whether creativity is measured by achievement, by laboratory tests, or by measurement of creativity in psychosis-prone individuals [8,31,32]). Moderately high Psychoticism is often a feature of individuals exhibiting the highest levels of achievement (not just in the sciences, but in the arts too) [8].

If the focus is revolutionary science, this makes sense in that setting science onto a new direction requires considerable independence from group norms, a certain selfish indifference to the feelings of others, as well as a mode of thinking which generates novelty. By contrast, a low Psychoticism individual would probably be too inclined to obey orders and too fearful to risk societal sanctions and too logical in their thought processes to generate and pursue disruptively original (i.e., creative) work. Low Psychoticism would therefore be a desirable trait for normal scientists, but undesirable for revolutionary scientists.

In conclusion, 'genius' probably entails moderately high Psychoticism. And, if correct, this has important implications for the selection of scientific personnel, since creativity is inversely correlated with Agreeableness and Conscientiousness. Therefore the modern type of scientific career structure – which enforces high levels of Conscientiousness, and which favours an Agreeable and socially compliant personality type – will not merely fail to select creative scientists: such a career structure will actually tend to exclude creative people.

Revolutionary science institutions should be selecting positively for high IQ and creativity/ moderately high Psychoticism

So, assuming that top level, elite scientific education and training institutions aim to select the highest levels of genius – i.e., those potential revolutionary scientists who are capable of changing the direction of their subjects – then modern selection methods and career structures will both need to change.

In the first place, elite institutions will need to know the IQ of applicants. As explained above, the particular value of IQ testing comes in identifying under-achievers whose high IQ is not reflected in high exam performance. These people may have lower Conscientiousness which impairs their performance at tasks which do not much interest or engage them. However, if their level of perseverance is sufficient to get them to the point of independent research, then their Conscientiousness may be high-enough to allow for very hard and sustained work at self-chosen problems which provide much more immediate reward. So that someone who found school and undergraduate college boring, and was thereby lacking motivation, may be altogether more driven when tackling a self-chosen problem. And selecting high IQ scientists of only-sufficiently-high Conscientiousness should also serve to increase the proportion of moderately high Psychoticism individuals – hence those who have the potential to become creative and revolutionary scientists.

Creativity cannot, at present, be directly selected-for. Although there are some psychological tests of creativity [6,8,31,32], these are of uncertain validity especially at predicting the high levels of creativity required by revolutionary science. However, elite scientific institutes could and certainly should avoid their present practice of (unintentionally) selecting against creativity.

For example many elite college application procedures (inadvertently) currently select against creativity when they ask for evidence of altruistic and sociable behaviours from their applicants – evidence of such activities as community service, participation in team sports, administrative responsibility, or memberships of drama or musical groups. Choosing the most 'Agreeable' students may make for a more pleasant and stimulating social environment and a more friendly and compliant student body. However, this strategy of excluding asocial or awkward individuals is a policy that is highly likely to lower the ceiling of achievement of the best science graduates.

On the other hand, less-selective 'normal science' educational and training institutions – who aim to educate and train personnel for reliable but more routine accomplishment at technical and administrative tasks, or functions that require close attention to detail – may be more legitimately interested in selecting for a higher average C – but inevitably at the cost of lower IQ. They may thus recruit a population of 'overachiever' students, whose attributes include the capacity for long hours of steady work; and such institutions may also wish to select for high Agreeableness which should improve the capacity for cooperative teamwork.

Whatever the aims of selection of scientific personnel might be – a combination of the results of examinations with IQ tests allows a more precise, informative and objective estimate of individual aptitudes than the current situation of using examinations alone.

Transcendental truth-seekers

In a nutshell, I am suggesting that:

1. Educational attainment depends on IQ × C; but IQ and C are not closely-correlated.
2. Modern education has progressively raised the floor for C (by lengthening the educational process and by changes in educational evaluation methods).

3. Educational attainment therefore nowadays increasingly rewards *C* in preference to IQ.
4. Yet revolutionary science still requires high levels of IQ, and the higher the better.
5. So, in revolutionary science where IQ is vital, selection of personnel should not be determined only or mainly by educational attainments; but this information needs to be supplemented with direct, formal IQ testing.
6. Furthermore, revolutionary science requires high levels of creativity; which are associated with moderately high Psychoticism trait – yet modern education and science selects very strongly in favour of Conscientiousness and Agreeableness and therefore enforces low Psychoticism.
7. So, the education, training and career structure of modern science tends to depress average IQ and cull creativity – which are the prime qualities requires for success in revolutionary science. Consequently, modern top scientists are likely to be less intelligent and creative than is desirable, and probably significantly less intelligent and creative than top scientists used to be.

In the past, the education and training of a scientist was a much shorter process – with many scientists reaching a position to do independent research by their middle-twenties. This shorter process imposed a much lower requirement for both Conscientiousness and Agreeableness – because for a moderately conscientious person the end was not impossibly remote and relatively few years of unpleasant effort provided access to desired goal, and a dis-Agreeable person did need to get along with a long series of bosses and their teams – any of whom might sabotage his career.

Also, in the past educational ability was more often measured using relatively-infrequent, timed and supervised, previously-unseen formal examinations during which the examinee would need to work fast to organize their knowledge. Such formal examinations are likely to be more 'g-loaded' (i.e., correlate more strongly with IQ) than the greater emphasis on frequent 'course work' which has characterized educational systems over recent decades – course work tends to reward Conscientiousness over IQ compared with formal exams and be preferred by more Conscientious and less intelligent students [33].

To return to the original question of why top scientists are so dull nowadays – the conclusion is that scientists are dull mainly because the progressive increase in the requirements for long-term plodding perseverance and social inoffensiveness has the effect of deterring, driving-out and failing to reward too many smart and creative potential scientists before they ever get a chance to engage in independent research. And maybe even more smart and interesting people are lost from science due later on to the requirement for so much planning and administration. Since the people who nowadays eventually emerge from the ever-lengthening pipeline of scientific training are quite different from the scientists of 50 years ago, they naturally tend to move science even further in the direction which created their own success. So that modern scientific leader often elevate the requirements for very long periods of tedious and scientifically-irrelevant activity, and judge scientists mainly by their capacity for steady and reliable production and teamwork. These requirements will tend to act against both creativity and intelligence.

It seem inevitable that the changes in selection process in science over the past several decades will have reduced both average IQ and creativity among those who have been through the full professional training process. Such changes would be expected particularly to damage performance in revolutionary science, but might even enhance performance in normal science where perseverance and sociability (assuming at least moderately high IQ) are likely to be more crucial to success. Indeed, this is presumably the reason why such changes have occurred, since the great majority of scientists are working in normal science, so the requirements of normal science therefore tend to dominate [2]. However, the magnitude of the effect on reducing IQ and creativity has not been measured and constitutes a subject deserving of future empirical study.

Instead of having an educational and career structure which selects for superhuman Conscientiousness and makes-do with whatever intelligence and creativity happen to be left-over; in revolutionary science we need a system which selects for superhuman intelligence and high creativity – and requires only enough Conscientiousness to ensure that independent scientists with a vocation for their work are motivated to put in the long, hard hours to solve those self-chosen problems that have come to enthral them, and only enough Agreeableness to exclude psychotics and psychopaths.

Selecting elite scientists on the basis of high and IQ and moderately high Psychoticism – implied by Eysenck's research [8] – may sound like a recipe for disaster, since these ingredients resemble a formula for gifted charlatans and con artists. A further vital ingredient is necessary: that elite scientists must have a vocational devotion to transcendental values of truth. In his magisterial study of the pinnacles of human accomplishment [34], Charles Murray concluded that achievement of genius was nurtured by social systems in which transcendental values were a living presence. Great revolutionary science is therefore a product of transcendental truth-seeking individuals working in a truth-seeking milieu.

It is truth-seeking which distinguishes a great independent-spirited scientist from mere brilliant charlatans and confidence tricksters who seek nothing higher than to use professional science in pursuit of their own selfish ends. Of course, making such a distinction, i.e., detecting truth-seeking, requires a scientific system that explicitly and in practice values transcendental truth-seeking above social virtues of perseverance and sociability – and such a perspective is uncommon within science nowadays. Lacking the living presence of such transcendental values, science has lapsed back into valuing social virtues for their own sake, with peer approval as the highest court of appeal, the ultimate validation [35]. Unsurprisingly such a science will over-promote *C* and *A*, and undervalue IQ and creativity.

The problem is that the current scientific leadership themselves often lack the trait of truth-seeking, and would not be able to detect it in others. This implies that revolutionary science (or 'pure' science) may need to be rebuilt on the basis of a new 'apostolic succession' of truth-seekers; starting from that minority of intelligent and imaginative top scientists who have managed to buck the trends and land professional positions of high status and authority [36].

People characterized by very high IQ, and moderately high Psychoticism might well be regarded as brilliant, but too selfish, unstable and/or foolish for everyday social purposes. But strange and luminous fools seem to be precisely what is most needed for successful revolutionary science. And modern society needs a place where clever, antisocial, imaginative people can do good and be prevented from inflicting the social harm than can result from ability and fantasy unconstrained by common sense, generosity or sensitivity to group norms. Science should be one such place: a place which should welcome and nurture inspired oddballs – so long as they are also vocational truth-seekers.

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