ON THE NOTION OF MATHEMATICAL GENIUS: RHETORIC AND REALITY

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Abstract. The existential hypothesis of mathematical 'genius' rests irrefutably with the affirmative. We can't all be one of course—that sublime solopreneur in creativity—but we may still contribute to research as lesser mortals. This short essay attempts to explore what the notion means to both us and non-mathematicians.

> *"Taste is confin'd to rules, it moves in chains,*
> *Genius those fetters and those rules disdains;*
> *No bands can hold her when she upward springs,*
> *No storm can stay the thunder of her wings,*
> *O'er fields of blood she takes her wandering flight,*
> *And calls from death the shrieking ghosts of night."* ...
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> John Blair Linn, *The Powers of Genius* (1801)

1 Concept and Perception

There is a growing body of research that asserts intelligence is a highly heritable and polygenic trait, so that many genes interact to generate and unlock its multi-faceted kernel, each with a small effect size whose collective imprint is non-negligible. Debated for decades, with inputs from groups such as bioethicists, social scientists and educationalists who dwell in a variety of non-neutral territories, its visibility as a complicated topic that affects us all by default is guaranteed. At one extreme of attendant nomenclature, the word 'genius' stands for something quite different, however—an almost magical endowment which sits alone and demands a separate kind of interrogation. It has strong implications and suggestive overtones in the minds of people, especially when applied to a caricature mathematician who is assumed to echo something of the drama in the poetic imagery above. The notion of an inexplicable (and ideally repeatable) flash of unaccountable vision, wrapped up nicely in the term 'genius', appeals to a fair portion of the nation as an expedient interpretation of any kind of illustrious, innate and instinctive mathematical 'episode', but reveals flawed understanding of the way we really work. Used in this fashion, it has become a misnomer to anyone who has been in the game of mathematics at research level for a while, and nowadays its overuse constitutes merely a trite generic convenience that dilutes the very thing it is supposed to describe (a similar example is found in an ex professional footballer who, almost overnight, morphs into a pundit accorded the status of 'legend').

Most of us encounter sudden and startling bursts of insight every now and then, though they invariably possess neither the impact nor the frequency to qualify us for membership of any select elite deserving of reverence and exaltation. We, the masses of 'ordinary' mathematicians, still contribute significantly to the field(s) in which we work—for the array of research problems available to occupy our interests is vast—where even only modest successes are typically the hard won fruits of endeavour, patience and tenacity (augmented, maybe, by a dose of luck); there are no shortcuts, and congenital talent plays only a part. The vast majority of practitioners are slow burners, so to speak, having to be satisfied with any sporadic rush of intense penetration

into, or resolution of, a problem in a manner that passes as impressive—even then, as pleased as one might be when it comes our way, what we have before us and what we will have undergone amount to only very mild versions of things that are actually associated with 'genius'.

Some films have attempted to portray the phenomenon—or something akin to it—through biography and have done so reasonably well (*A Beautiful Mind* (2001), *The Imitation Game* (2014) (plus the more authentic forerunner *Breaking the Code* (1996)), *The Theory of Everything* (2014) and *The Man Who Knew Infinity* (2016), though not without taking liberties with source material), but others—such as the implausible *Goodwill Hunting* (1997), the ridiculous *Proof* (2005), the short (esoteric and unilluminating) *Rites of Love and Math* (2010), along with the absurd and platitudinous brief drama *The Calculus of Love* (2011)—are fictional pieces whose narratives have at best a tenuous link with the reality of an extraordinary ability that seems unfathomable.[1] The layman may well carry an internal picture of mathematical 'genius' that is shaped primarily by the latter—leading in consequence to sweeping and fallacious conclusions about mathematicians—which is an unavoidable shame. I suppose they do have a use to the extent that the general populace is able to appreciate that mathematical 'cleverness' can be acute and unforeseen, but neither the plots nor *dramatis personae* inform or educate correctly about those quintessential qualities that mark some people out as truly remarkable; maybe it is only through carefully planned documentaries,[2] or occasional published interview, that the public can be exposed to spectacular mathematical inspiration which is presented in a context accessible to non-specialists and yet faithful to the commanding institution of mathematics.

There have been a series of geniuses amidst us (Gauss, Euler, Ramanujan, Newton, Riemann, for instance—names redolent of the history and traditions of mathematics who exhibited a variety of dispositions and delivered some astonishing results), though they are very few and far between; rare breeds indeed, they form a most exclusive club where mathematical legerity, daring, innovation and courage were unmistakably at the fore, together with the odd dash of insolence, cavalier audacity and pioneering temerity. It would be unfair to try to index living contenders for fear of subjective error and omission, but Australian Terence Tao is one of them, as are the Englishman John Conway and reclusive Russian Grigori Perelman in my opinion, all superb operatives imposing their own brands of adroitness and artistry that go well beyond the habitual types of erudition, flair and other aptitudes embodied in much of our research. The genealogy of mathematics urges us to be always be conversant with those eras in which its disciples lived when we attempt to gauge their accomplishments and legacies, on which basis notables such as Pythagoras, Leibniz, Descartes, Wiles, Hawking, Erdős and Euclid may be elevated to the rank of genius or thereabouts, along with a small number of others who enjoy a richness of anima that is *hors concours*. We should not forget that environmental/external factors influence individual opportunities to flourish mathematically, and barriers still persist to this day—from constraining parental impositions, unhelpful gender typecasting, inflexible school teachers, ever changing government policies and humdrum university programmes to xenophobia and poverty—so we must never take the possibility of genius for granted but rather handle it with care so as to reap its benefits.

2 Delusion, Quest and Image

On the matter of genius those that wrongly align their attributes with it run the risk of bullishly focusing on so called 'big issues' on which headway remains unsurprisingly elusive, or else they confine themselves to self-restricting (perhaps even slightly obsessive) lines of thinking that limit their horizons and may disclose autistic propensities; the outwardly strange, however, has overwhelmingly nothing at all to do with 'genius'. Deleterious emotional difficulties, psychogenic disorders, and the like—sometimes borne of an almost inevitable sense of discouragement that comes with unrealistic expectations or perhaps developed through a loss of healthy scepticism

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[1] I am here not including the 2012 release *Travelling Salesman* (which centres itself around the moral/ethical dilemmas involved in solving a fundamental mathematical problem with some major implications for society), nor the pleasant but predictable drama *Gifted* (2017) in which a child prodigy's inherited mathematical promise (from her deceased mother) very much plays second fiddle to interpersonal family relationships in the storyline.

[2] Such as Andrew Wiles' journey towards a proof of Fermat's Last Theorem aired, to wide approval, by the B.B.C. as a *Horizon* episode in 1996 (*Fermat's Last Theorem*), or the award winning 1993 piece *N is a Number: A Portrait of Paul Erdős* which, filmed over four years of his life, gave a wonderful snapshot of this humble and itinerant man who was an unparalleled collaborator and truly the most prolific mathematician of the last century.

in their work—await some, too, sadly (*A Beautiful Mind* and the 1998 release *Pi* are reminders that madness stalks specific temperaments, waiting for a propitious moment to strike). Self-promoting delusion steers others to take on the role when accompanied by a dose of conceit, deliberately ticking the boxes of stereotypic eccentricity and superficially majestic archetype while, defying parody, basking in a warm haze of artificiality and ritualistic conformity. Motivated by a false impression of personal acumen, or maybe driven by a fierce competitiveness, people will seek endorsement commensurate with a singular demonstration of their overestimated intellectual wealth, expending wasted energy on the quest to become an academic plutocrat with weighty profile as a paragon of apotheosis and magnificence; this is no way to be either, and such a charlatan—unlike someone who has maladaptive genetic traits while showing flashes of brilliance—warrants little or no sympathy. Still yet there are the unfortunates who find the discipline utterly trivial when young but—through an excess of early praise and/or absence of challenge—develop a laziness, complacency and lack of inner steel (persistence is often critical in mathematical research) that causes them to falter at a later stage, at which point the prospect of becoming an acclaimed mathematician (or even better) is gone and they may fail to understand why. Many who might reach the lush plains of mathematical perfection fade away as unnoticed *manqués* for other reasons (on a wider point, a reputable study published some years ago reported that out of 200+ 'gifted' children whose progress was followed into later life, only 3 per cent went on to fulfil their early potential; other investigations, conducted since then, substantiate these findings).

The above are illustrative types—some of whom are quasi-skeuomorphic impostors attempting to mimick or project bona fide 'genius'—and while not credible they will always engender a certain attraction as idiosyncratic oddities. At ground level the reality of our vocation is that achievements are in fact built almost entirely on systematic and dedicated study, drawing on the constant and accumulative absorption of material disseminated by the wider mathematical community so as to build up an abundant reserve of knowledge, methodologies and strategies—in other words, they are founded on a real investment of purposeful and sustained effort, which is a recurrent *modus operandi* trademark of most of us (trailblazers included) and weakens the role of I.Q., such as it might have one, as a metric of performance prediction or pre-ordained attainment.[3] It is generally agreed that there is usually no substitute for spending time working in an area of mathematics in order to foster the exciting prescience that foreshadows an unanticipated breakthrough of some kind, and this definitely applies when the concepts involved are deep or complex (though not in the case of Srinivasa Ramanujan, who appeared from nowhere as a complete amateur with no formal training whatsoever and is unique in this respect). The popular depiction of the loner who somehow manages to find a breathtakingly original answer to an important question that has confounded the experts—discarding established theories and blueprints of the literature on the way—is charming and romantic, but it is also a wildly inaccurate one, at least in modern day mathematics; genuinely *ex nihilo* instances of such supreme perception remain the exception, rather than routine events. Instead of being given a proper sense of denotation, the characteristic of 'genius' has been left to those whose predilections favour simplistic labels and who cannot grasp what it takes to be even a half-decent mathematician, let alone anything more—it makes for a poor sort of external validation that, because it is viewed through the prism of ignorance, is a misrepresentation of a real and entrancing deviation from the conventional and the mainstream.

3 Mystery and Reward

By and large, the world of mathematics moves forward not through the inventiveness, bold enterprise and finesse of an outstanding minority, but rather from those toils and exertions of the many who—reaching down into themselves on a regular basis—bring to bear a variety of approaches to research which are profitable in yielding a multitude of mostly incremental advances. While 'genius' does exist, it does so as a particularly unusual mental commodity and has to a degree been hijacked as an myth overplayed by those who reside beyond the boundaries of our domain

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[3]By way of a short digression, note that the designation 'genius' was abandoned as an I.Q. descriptor as long ago as the late 1930s, and there have been reported instances where those recorded as having low I.Q. scores when young have gone on to become Nobel Prize winners; current thinking concludes that a minimum level of I.Q. (approximately 125) is necessary, but not sufficient, for that thing measured as 'genius', and must be combined with other so called nature and nurture factors.

where it is furnished with half-truths and exaggerations that are difficult to shake off. It is indisputably far less common among mathematicians than it is made out to be, and we just have to live with this—it goes with the territory, so the saying goes. Geniuses are without doubt masters of discerning perspicacity, executing a huge cognitive compression (that serves both immediacy of progress and future recall) and working with parameters of the (sub)conscious without demand for too much physical delineation; for these people any utilitarian/aesthetic components to the work will almost always be subordinated to the challenge in hand or the mathematical flight of fancy involved, and when called upon procedures such as absorbtion, compliation, visualisation, abstraction, extraction, distillation, compartmentalisation, stratification, processing, and so on, are undertaken in a manner set apart from the norm, prosecuted by forces whose dynamics can be visceral and aided by unorthodox toolkits at their disposal. That said, it is not at all clear what 'genius' is, so any attempt to define it is rather pointless and we are left to admit that it has a mysterious aspect whose essence is intangible and transcendent ("*Say what is Genius? Words can ne'er define/That power which [leaps] from origin divine;/...*" [2, p. 13]) but nevertheless takes a recognisable form to mathematicians when it chooses to manifest itself from the hidden recesses and neurological hinterlands of the brain. We might also reflect on the thought that the dividing line between the genius and the prodigiously bright is perhaps not necessarily a sharp one either, and a person might have periods when transitory movement into those grey areas straddling them occurs as the calibre of that produced rises or diminishes with shifts in circumstance and mood.

Mathematicians are privileged in so far as individuals at the top of the tree, as it were, do have the opportunity to etch their name into the annals of time in ways not available to academics working in other areas. He wasn't writing about the idea of 'genius' as such, but in his celebrated 1940 monograph [1] this is what the forthright G.H. Hardy had to say about the rewards to be gained from being a mathematician *par excellence*:

> "If intellectual curiosity, professional pride, and ambition are the dominant incentives to research, then assuredly no one has a fairer chance of gratifying them than a mathematician. His subject is the most curious of all—... It has the most elaborate and the most fascinating technique, and gives unrivalled openings for the display of sheer professional skill. Finally, as history proves abundantly, mathematical [triumph], whatever its intrinsic worth, is the most enduring of all. (p. 80). ... 'Immortality' may be a silly word, but probably a mathematician has the best chance of whatever it may mean. Nor need he fear very seriously that the future will be unjust to him. (p. 81). ... on the whole the history of science is fair, and this is particularly so in mathematics. No other subject has such clear-cut or unanimously accepted standards, and the men who are remembered are almost always the men who merit it. Mathematical fame, if you have the cash to pay for it, is one of the soundest and steadiest of investments." (p. 82).

These are lovely quotes, penned by someone who spent his days at the sharp end of analysis and number theory (Hardy registered well up on the spectrum of cerebral functioning—something in which he took a good deal of comfort), and there is a permanence about them that fits well a discourse such as this which ponders what 'genius' is.

As a final thought, it is interesting to note that according to current research in psychology there are two phases to creative imagination in general, and these must apply in particular to the field of mathematics to an extent. '*Divergent* thinking' cultivates a capacity to generate a wide variety of ideas—all somehow connected to a main problem or topic—which tends to be supported by (fast and automatic) 'intuitive thinking'. Assisted by (unhurried and diligent) 'analytical thinking', one then needs to invoke '*convergent* thinking' to help evaluate proposals for their relevance and usefulness, allowing the right one(s) to be selected. Overlaying all of this, experience can be vital too at times, in the sense that the longer someone has worked in an area— and, importantly, both dared and allowed themselves to make mistakes—the more likely (s)he will be to conceive schemes, architectures and prototypes from which to hand-pick the best. They surely seem familiar to all mathematicians in problem solving scenarios, and the more talented among us tap into them perhaps without knowing exactly what they are and how enabling they prove to be in pushing forward the frontiers of knowledge. On a side note, Edward C.F.P. de Bono (a living Maltese physician, psychologist, philosopher, author, inventor and consultant)

gave us the phrase *lateral thinking* in the 1960s and has written much about pragmatic methods on which we can draw to make our minds more creative through attending to, and improving skills in, productive reasoning. While benefiting from the commercial exploitation of his ideas, their reliability and efficacy have been questioned in some quarters by insufficient empirical evidence, and the whole issue of creativity (and how we might nourish conditions in which it can take place) remains a pertinent and sometimes contentious one affecting mathematicians and non-mathematicians alike.

4 Closing Comments

We are now able to map the inner workings and behaviours of humans as never before, yet 'genius', as a personality classification indicating formidable strength of capability, has become too tired a cliché to hold expressive accuracy (it is a casualty of modern media that—exercising an eager willingness to alter etymological nuances—chooses to deploy the terminology for impact) and never more so that when referring to a mathematician. To have been bestowed the status of 'genius' from one's coterie of peers is, however, the ultimate market return from the stocks and shares of mathematical repute for scarceness is undeniably its real *valeur*, enhanced by the psychologies surrounding it as a natural gift. Those on whom the accolade is legitimately conferred are venerated by us as professionals, while they continue to captivate and enchant the imagination of outsiders—testimony to an intrigue with the purest form of reasoning, logic and causal argumentation known to man, and confirmation of the metaphorical pedestal on which these are quite rightly placed. We should all salute the few that, as stars in the mathematical firmament with a dazzling glow, dance to new mathematical melodies and harmonies orchestrated in their own distinctive style. They take on the role of flagships for those blessed with consummate prowess, able to glimpse profound truths from a loftier perspective and who, as Hardy would have aptly put it, are " 'Fellows of another college' ". [1, p. 81].

I finish where I began, that is with words by Linn taken from an introductory explanation of the rationale and remit of his 1801 poem—a substantial offering (of three sections) written after he was settled as a preacher in the First Presbyterian Church in Philadelphia from 1799, during which time he exerted himself with unwearied assiduity in the discharge of his clerical functions as he mingled the elegant avocation of a poet with the grave and severe duties of a minister ("The different faculties which are subservient to genius, have frequently undergone investigation; while genius itself, has seldom been examined with care. Genius receives assistance from all the intellectual powers; but it is however, to be carefully distinguished from them." [2, p. 5]). Though writing of those in the field of literature, he still captures more than an element or two of the pre-eminence so integral to that unquantifiable thing we, as mathematicians, call 'genius':

> "Genius implies such vast comprehension, such facility in the association of ideas, as enable a person to call in the conceptions that are [required] to execute the design in which he is engaged. We shall always discover that great stores of materials have been collected by his [whim], and subjected to his judgment. He darts with rapidity over the fields of his investigation; and [by this] his ardour becomes more inflamed." [2, p. 7].

Quoting from the 17th century English poet John Milton he adds, verbatim, "The velocity of his motion sets him on fire, like a chariot wheel which is kindled by the quickness of its revolution."—this is as much true in mathematics as in the literary circles that Linn reviews.

What is mathematical 'genius' exactly, whose creative spirit and dictates, once roused, must be obeyed? I do not arrogate to myself any right to define it, hoping only that this short essay piques the attention of readers and provides some salient points for consideration so that others might scrutinise it under their own lines of enquiry—as I have here—and make of it what they will.

References

[1] G. H. Hardy, *A Mathematician's Apology*, Cambridge University Press, Cambridge (2011 reprinted edition) (1940).

[2] J. B. Linn, *The Powers of Genius*, Asbury Dickins (Printer M. Maxwell, Columbia-House), Philadelphia (1801).

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