2005 MASTER-MIND LECTURE

Einstein

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Henrietta Hertz and the Master-Mind Lectures

MISS HENRIETTE HERTZ, the Maecenas of these lectures, died in 1913.[1] She bequeathed the *Palazzo Zuccari* in Rome, which she had reconstructed, to the *Kaiser-Wilhelm-Gesellschaft*[2] in Berlin: 'With the aim that, in accord with its tradition, it shall serve the lasting cultivation of art and science.'[3] In that same year, Albert Einstein was offered a position as a Permanent Member of the Prussian *Akademie der Wissenschaften*, with the promise of heading the Physics Institute of the *Kaiser-Wilhelm-Gesellschaft*. He moved to Berlin in 1914 and, had Miss Hertz lived, it is not improbable that the two would have met there.

Earlier, Miss Hertz had provided for the endowment at the British Academy of three lecture series.[4] One of these is the Master-Mind lectures, in each of which:

Read at the Academy 19 July 2005.

[1] For her biography, see Julia Laura Rischbieter, *Henriette Hertz Mäzenin und Gründerin der Bibliotheca Hertziana in Rom* (Stuttgart, 2004).

[2] In 1948, it was re-founded as the *Max-Planck-Gesellschaft*.

[3] 'In der Absicht, daß dieselben ihrer Tradition gemäß dauernd der Pflege von Kunst und Wissenschaft dienen sollen'. See ibid., p. 169. Her will adds: 'Zu diesem Zweck ist in den unteren Räumen, die von Federico Zaccari selbst ausgemahlt wurden, eine kunst-historische Bibliothek eingerichtet worden, die unter den Namen "Bibliotheca Hertziana" dort für immer ihre Heimstätte finden soll.' [For this purpose, in the rooms of the lower floor, decorated by Federico Zaccari himself, a Library of Art History shall be installed, which, under the name Bibliotheca Herziana, shall find its home there in perpetuity.]

[4] See Rischbieter, *Henrietta Hertz*, p. 107. Her niece Alide's husband, Sir Israel Gollancz, was a founding member and first Secretary of the British Academy from 1902 until his death in 1930.

Proceedings of the British Academy **151**, 423–458. © The British Academy 2007.

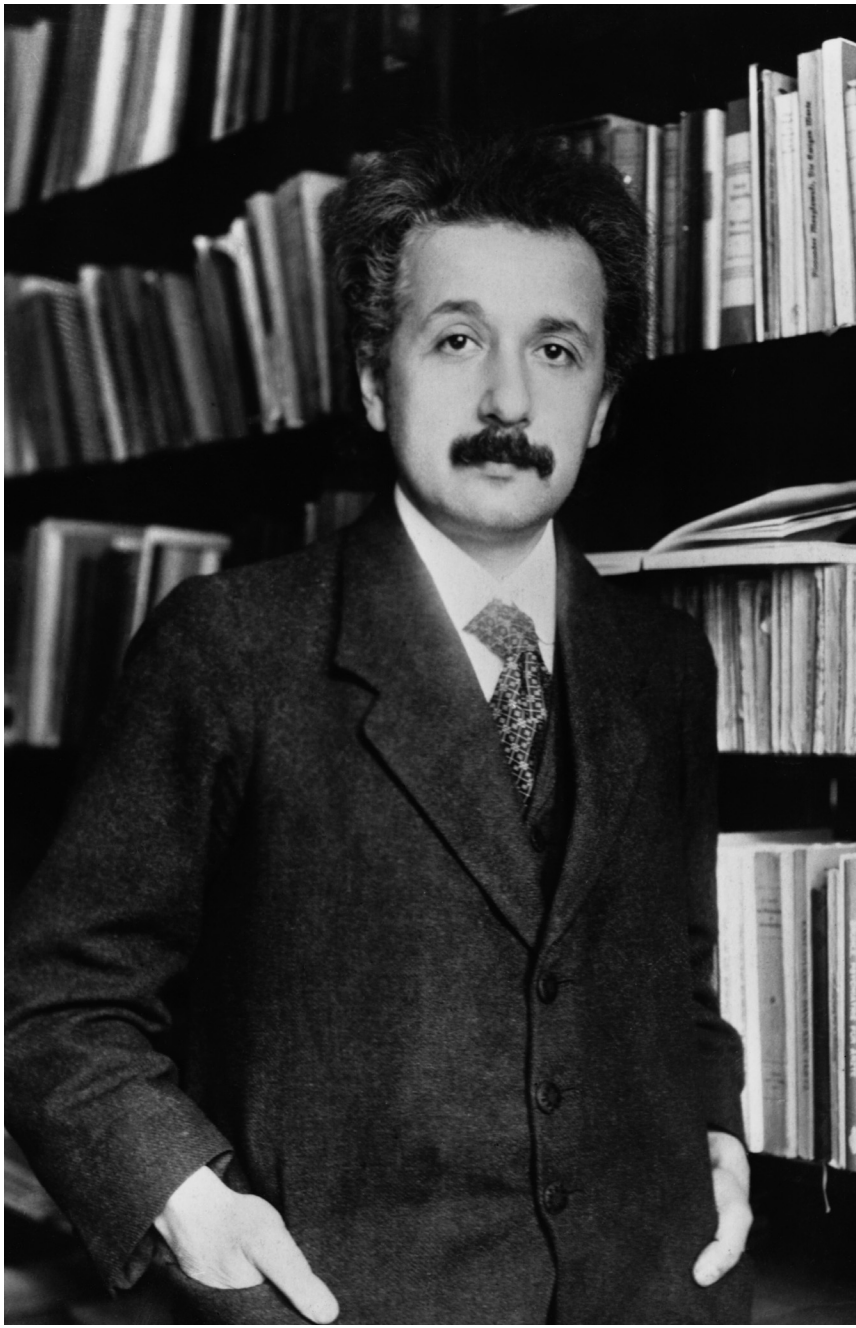


Figure 1. Albert Einstein in 1916. © Hulton-Deutsch Collection/CORBIS.

> some Master-Mind [is] considered individually with reference to his life and work especially in order to appraise the essential elements of his Genius: the subject to be chosen from the great Philosophers, Artists, Poets, Musicians.

The first lecture was given in 1916, the year in which Einstein published the definitive account of the general theory of relativity.[5] He considered general relativity to be his greatest accomplishment and it certainly manifested 'the essential elements of his Genius'.

Scientists were not included in Miss Hertz's pool of candidates, and in the sixty-two previous Master-Mind lectures, only *three* natural scientists have been chosen as subjects: Sir Isaac Newton (1927 lecture by C. D. Broad); Charles Darwin (1959 lecture by Gavin de Beer); and Eratosthenes (1970 lecture by P. M. Fraser).[6] I am a bit perplexed about the subject of the 2002 lecture, Sigmund Freud: should he be included among the natural scientists? But discussion of that question is best reserved for my own psychoanalysis.

Of course, Einstein has been justly characterised as a 'philosopher-scientist',[7] so perhaps he can be slipped in under that rubric. And indeed, in trying to fulfil Miss Hertz's behest, in addition to science I shall invoke some philosophy as well as considerable psychology,[8] not a little poetry; several works of art; and even one reference to music. But before turning to the topic proper of this lecture, I shall discuss a major obstacle to an appraisal of 'the essential elements of his Genius': the widespread image of Einstein as *Magus*.

The scientist as Magus

Tony Rothman recently has summarised the problem:

> Strangely, the festivities embody a paradox, perhaps a double paradox: On the one hand, more has been written about Einstein than any scientist who ever lived, and to say anything fresh is almost impossible. The superfluity can only cause problems for publishers and conference organizers wishing to be original. On the other hand, Princeton's publication of the *Collected Papers* as well as

[5] 'Die Grundlage der allgemeinen Relativitätstheorie', *Annalen der Physik*, 49 (1916), 769–822.

[6] Fraser starts by remarking: 'I am not convinced that Eratosthenes qualifies for discussion as a Master Mind', so perhaps one should say only *two* scientists have been justly honoured.

[7] The volume dedicated to him in the *Library of Living Philosophers* is entitled *Albert Einstein: Philosopher-Scientist* (La Salle, IL, 1949).

[8] In 1913 psychology was still in the process of separating itself as a discipline from philosophy.

> diligent sleuthing by historians have allowed a more nuanced view of Einstein to emerge. Any subtleties are so utterly defeated by the public mythology surrounding the man, however, that the traditional incantations continue to be repeated by journalists and scientists alike.[9]

In other words, Einstein has become a Magus. I am referring not to John Fowles well-known novel *The Magus*,[10] but to a homonymous work by Francis Barrett,[11] the full title of which constitutes a précis of its contents.[12] It has been described as:

> one of the primary sources for the study of ceremonial magic, and for a long time . . . one of the rarest and most sought after of the 19th century grimoires. Barrett's magnum opus embodies deep knowledge of Alchemy, Astrology, and the Kabbalah. . . . Written in 1801 in the middle of the 'Age of Reason', sandwiched between Newton and Darwin, this was possibly the last epoch that a

[9] 'What Einstein Knew: One Year and Five Papers That Changed Physics Forever', *The American Scholar*, 74 (2005), 127.

[10] *The Magus* (New York, 1965); rev. edn. (London, 1977). I have been a fan of the book since its publication.

[11] 'Barrett, an Englishman, claimed himself to be a student of chemistry, metaphysics, and natural occult philosophy. He was an extreme eccentric who gave lessons in the magical arts in his apartment and fastidiously translating the Kabbalah and other ancient texts into English. . . . Barrett's belief in magical power might be summed up this way: The magical power is in the inward or inner man. A certain proportion of the inner man longs for the external in all things. When the person is in the appropriate disposition an appropriate [sic] between man and object can be attained. The Magus also served as an advertizing tool. In it Barrett sought interested people wanting to help form his magic circle. It is uncertain whether he accomplished this goal, but the British historian Montague Summers claims Barrett did, and turned Cambridge into a center for magic.' Alan G. Hefner, article on 'Francis Barrett' in *The MYSTICA|An on-line encyclopedia of the occult, mysticism, magic, paranormal and more* <www.themystica.com/mystica>.

[12] *The Magus, Or Celestial Intelligencer, Being A Complete System of Occult Philosophy in Three Books, Containing the Antient and Modern Practice of the Cabalistic Art, Natural and Celestial Magic, &c.; shewing the wonderful Effects that may be performed by a Knowledge of The Celestial Influences, the occult Properties of Metals, Herbs, and Stones, and the Application of Active to Passive Principles. Exhibiting the Sciences of Natural Magic; Alchymy, or Hermetic Philosophy; Also The Nature, Creation and Fall of Man. His natural and supernatural Gifts; the magical Power inherent in the Soul, &c.; with a great Variety of rare Experiments in Natural Magic. The Constellatory Practice, or Talismanic Magic; The Nature of the Elements. Stars, Planets, Signs, &c.; the Construction and Composition of all Sorts of Magic Seals, Images, Rings, Glasses, &c.; The Virtue and Efficacy of Numbers, Characters, and Figures, of good and evil Spirits. Magnetism, and Cabalistic or Ceremonial Magic; In which, the secret Mysteries of the Cabala are explained; the Operations of good and evil Spirits; all Kinds of Cabalistic Figures, Tables, Seals, and Names, with their Use, &c. The Times, Bonds, Offices and Conjuration of Spirits. To Which is Added Biographia Antiqua, or the Lives of the most eminent Philosophers, Magi, &c. The Whole illustrated with a great Variety of Curious Engravings, Magical and Cabbalistic Figures, &c*. (London, 1801).

work like this could be composed[13] see <www.sacred-texts.com/grim/magus/>).

Einstein is not the first savant whose public image has blended with that of such Magi, possessed of occult powers. The Magus *par excellence* of the West-European tradition undoubtedly is Dr Johannes Faustus, whose image has inspired countless work of art—to say nothing for the moment of literature—from the most banal to the most sublime.

Learned Faustus was a medical doctor, and we shall return to him in due course. Coming closer to our subject, who does not recall Alexander Pope's lines?

> Nature and Nature's Laws lay hid in night;
> God said, Let Newton be!—And all was light.

These lines pale—if not as poetry, then as praise—in comparison with Edmund Halley's *Ode* to Newton's *Principia:*

> Mortals arise, put aside earthly cares,
> And from this treatise discern the powers of a mind sprung from heaven,
> Far removed from the life of beasts, He who commanded us by written tablets to abstain from murder,
> Thefts, adultery, and the crime of bearing false witness,
> Or he who taught nomadic peoples to build walled cities, or he who enriched the nations with the gift of Ceres,
> Or he who pressed from the grape solace for cares,
> Or he who with a reed from the Nile showed how to join together
> Pictured sounds and to set spoken words before the eyes,
> Exalted the human lot less, inasmuch as he was concerned with only a few comforts of a wretched life,
> And thus did less than our author for the condition of mankind.
> But we are now admitted to the banquet of the gods,
> We may deal with the laws of heaven above; and we now have
> The secret keys to unlock the obscure earth; and we know the immovable order of the world
> And the things that were concealed from the generations of the past.
> O you who rejoice in feeding on the nectar of the gods in heaven,
> Join me in singing the praises of Newton, who reveals all this,
> Who opens the treasure chest of hidden truth,
> Newton, dear to the Muses,

[13] Given the current fervent interest in witchcraft, astrology and anti-rational credos in general—curiously combined as it is with an equally fervent worship of the latest technology (get your horoscope on the internet)—I consider the last statement wildly optimistic.

> The one in whose pure heart Phoebus Apollo dwells and whose mind he has filled with all his divine power;
> No closer to the gods can any mortal rise.[14]

Turning from poetry to art, there is William Blake's curiously ambiguous image of Newton, which has been interpreted variously as praising, mocking, or decrying Newton (Fig. 2).[15]

Einstein has inspired similar flights of ambiguous imagination. The attempt to characterise his sober scientific work as exotic esoteric lore started early, with the 1920s legend that only three other people could understand his theory of relativity. It would need a separate lecture to give even a brief history of the Einstein legend; so I confine myself to citing the names of a few books in English that make Einstein the universal Magus.

In 1930, George Bernard Shaw described Einstein as a 'maker of universes' and H. Gordon Garbedian echoed the phrase in the title of his book *Einstein: Maker of Universes* (New York and London, 1939). This was followed by: Lincoln Barnett's *The Universe and Dr. Einstein* (New York, 1946)—at least the universe comes first!—Nigel Calder's *Einstein's Universe* (New York, 1979), Michio Kaku's *Einstein's Cosmos* (New York, 2004)—presumably 'cosmos' was used because 'universe' was already taken, and J. Richard Gott's *Time Travel in Einstein's Universe* (New York, 2001). The Berlin Exhibition on the centenary of Einstein's *Annus Mirabilis* was more modestly entitled: *Albert Einstein: Chief Engineer of the Universe*.[16]

When Princeton University Press kindly suggested that I edit an annotated English translation of Einstein's 1905 papers, they suggested the title *Einstein's Miraculous Year: Five Papers That Changed the Universe*. I was able to persuade them to change it to *Five Papers That Changed the Face of Physics*.

Nor did the muse of poetry flag when confronted with Einstein:[17] Archibald MacLeish's 'Einstein' describes not the man but the Magus:

[14] *Ode on This Splendid Ornament of Our Time and Our Nation, the Mathematical-Physical Treatise by the Eminent Isaac Newton*. Cited from I. Bernard Cohen and Ann Whitman (eds.), *The Principia: A New Translation and Guide* (Berkeley, Los Angeles, London, 1999), p. 380.

[15] See Donald D. Ault, *Visionary Physics: Blake's Response to Newton* (Chicago and London, 1974).

[16] See the catalogue: Jürgen Renn (ed.), *Albert Einstein—Chief Engineer of the Universe: Documents of a Life's Pathway* (Weinheim, 2006).

[17] See Alan J. Friedman and Carol C. Donley, *Einstein as Myth and Muse* (Cambridge, 1985).

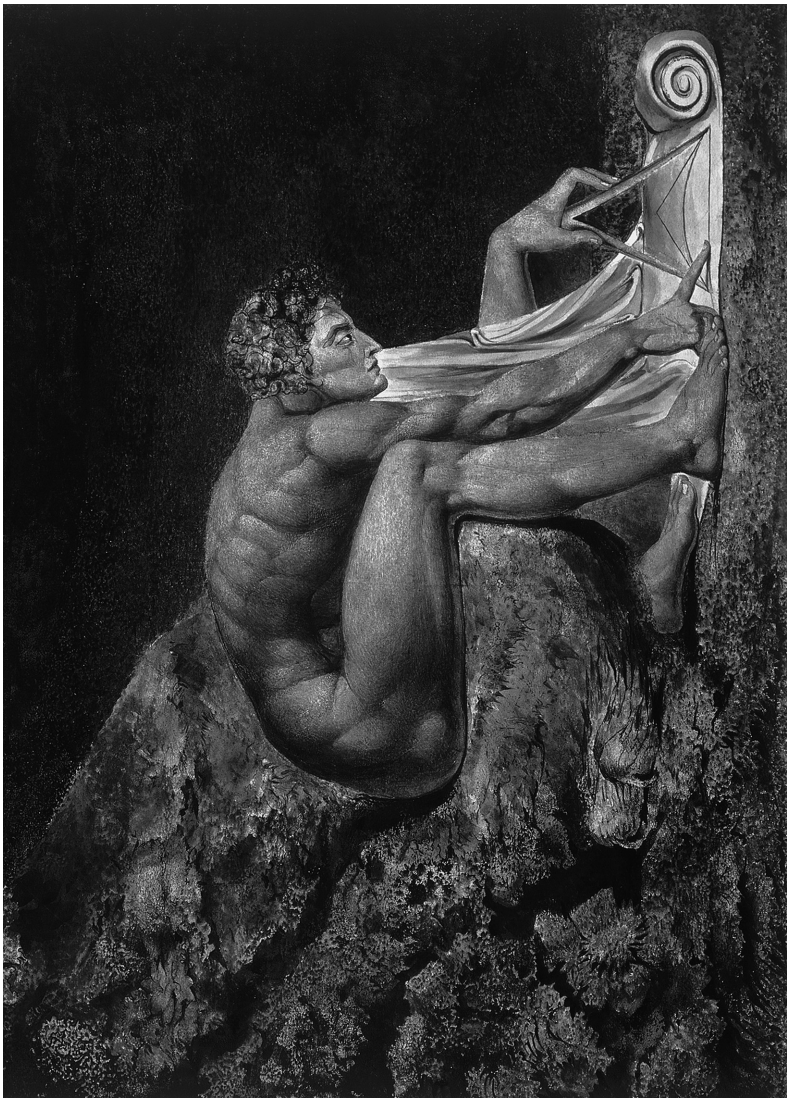


Figure 2. Newton, William Blake (1795). © Tate, London 2007.

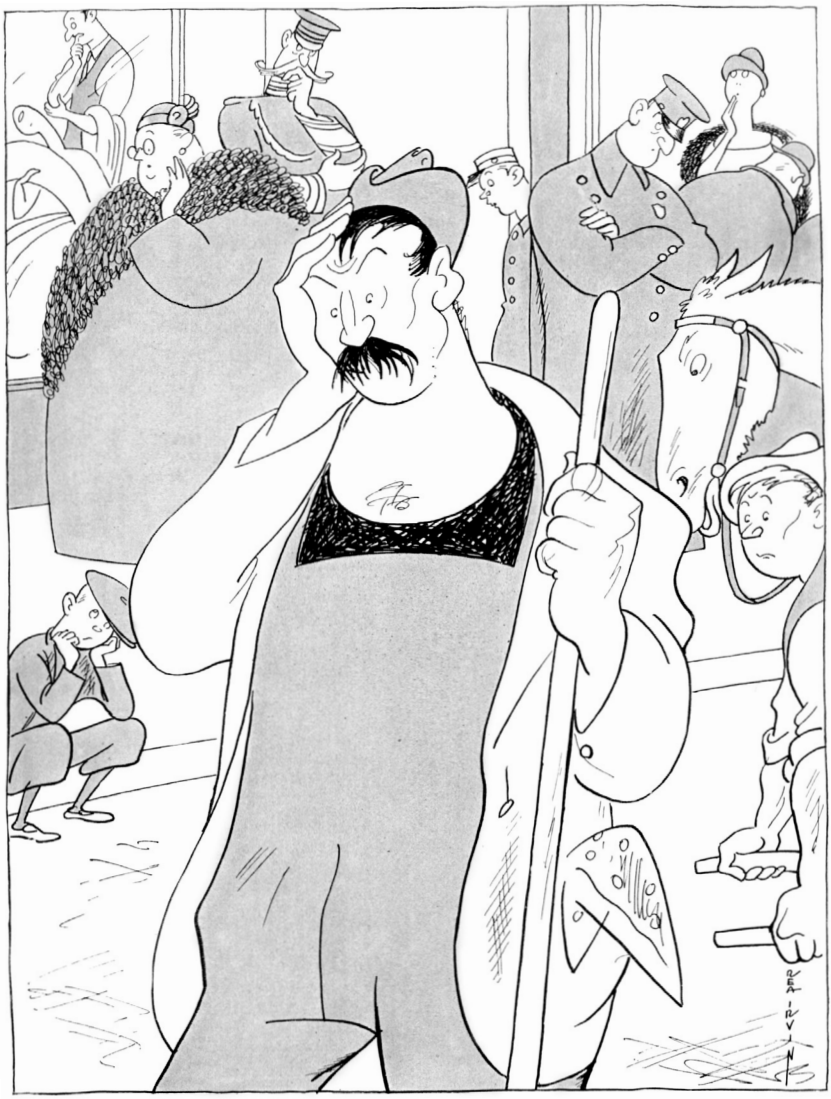
Nor could Jehovah and the million stars
Staring with their multitude of light,
Nor all night's constellations be contained
Between his boundaries . . .
He lies upon his bed
Exerting on Arcturus and the moon
Forces proportional inversely to
The squares of their remoteness and conceives
The Universe.
  Atomic.
  He can count
Oceans in atoms and weigh out the air
In multiples of one and subdivide
Light into numbers.
  If they will not speak
Let them be silent in their particles.
Let them be dead and he will lie among
Their dust and cipher them—undo the signs
Of their unreal identities and free
The pure and single factor of all sum—
Solve them unity.[18]

I believe that we shall better understand the public impact of semi-mythical figures such as Newton and Einstein—and Moses, Jesus, Muhammad and Buddha, for that matter—if we realise that, to the broad public, they are not mere men but Magi—figures who stand in some unique relation to the cosmos and whatever mysterious forces guide its destiny.[19] If they cannot create universes (as Shaw would have it), at least they have some mystical connection with our universe that enables them to penetrate its deepest secrets, unveil its hidden depths, engineer its destiny. This power may be exerted for good or for ill, for there is always some moral ambiguity associated with the image of the Magus. The popular—but mythic—image of Einstein as father of the atomic bomb, embodies that ambiguity.

Of course, when associated with the supposed incomprehensibility of his ideas, this oracular aspect can be put to humorous use, as in this cartoon from the *New Yorker* (Fig. 3):

[18] Written in 1926, cited from Friedman and Donley op. cit., p. 72.

[19] I recently secured a copy of the book that convinced me as a child that I wanted to study science, Norton Wagner's *Unveiling the Universe: Where We Are and What We Are as Told by the Telescope and Spectroscope* (Scranton, PA, 1936): If astronomy could unveil the universe, I wanted to be in on its secrets; and I am sure that I am not alone in having been so motivated to a career in science.



'People slowly accustomed themselves to the idea that physical states of space itself were the final physical reality.'

Professor Albert Einstein

Figure 3. Drawing by Rae Irvin from *The New Yorker.*

The grain of truth

As is usually the case for such widespread myths, there is an important grain of truth hidden in this storehouse of shamanism. If they do not create an *external* world, these larger-than-life figures do create an *inner* world. Of course, they do not create it out of whole cloth, and—most importantly—this world does not remain purely internal. Each manages somehow to impose at least a part of his or her inner world on the appropriate community (or communities) in the outer world. The larger this community, the wider the impact of their ideas, the more likely it is that their 'creator' will be elevated to the status of Magus.

This phenomenon has not gone unnoted by psychologists. Freud suggests that the creation of such an inner world begins in childhood:[20]

> Should we not look for the first traces of imaginative activity as early as in childhood? The child's best-loved and most intense occupation is with his play or games. Might we not say that every child at play behaves like a creative writer, in that he creates a world of his own, or, rather, rearranges the things of his world in a new way which pleases him? It would be wrong to think he does not take the world seriously; on the contrary he takes his play very seriously and he expends large amounts of emotion on it. The opposite of play is not what is serious but what is real. In spite of all the emotion with which he cathects his world of play, the child distinguishes it quite well from reality; and he likes to link his imagined objects and situations to the tangible and visible things of the real world. This linking is all that differentiates the child's 'play' from 'phantasying'.[21]

[20] 'Sollen wir die ersten Spuren dichterischer Betätigung nicht schon beim Kinde suchen? Die liebste und intensivste Beschäftigung des Kindes ist Spiel. Vielleicht dürfen wir sagen: Jedes spielende Kind benimmt sich wie ein Dichter, indem es sich eine eigene Welt erschafft oder, richtiger gesagt, die Dinge seiner Welt in eine neue, ihm gefällig Ordnung versetzt. Es wäre dann Unrecht zu meinen, es nähme diese Welt nicht ernst; im Gegenteil, es nimmt sein Spiel sehr ernst, es verwendet große Affektbeiträge darauf. Der Gegensatz zu Spiel ist nicht Ernst, sondern—Wirklichkeit. Das Kind unterscheidet seine Spielwelt sehr wohl, trotz ihre Affektbesetzung, von der Wirklichkeit und lehnt seine imaginierten Objekte und Verhältnisse gerne an greifbare und sichtbare Dinge der wirklichen Welt an. Nichts anderes als diese Anlehnung unterscheidet das "Spielen" des Kindes noch vom "Phantasieren".' Cited from 'Der Dichter und das Phantasieren', in *Gesammelte Werke, Chronologisch Geordnet*, vol. 7, *Werke aus den Jahren 1906–1909* (London, 1940), p. 214.

[21] Cited from 'Creative Writers and Day-Dreaming', in *The Standard Edition of the Complete Psychological Works of Sigmund Freud, Volume IX (1906–1908) Jensen's 'Gradiva' and Other Works* (London, 1986), pp. 143–4.

I remind you that the book[22] that includes Erik Erikson's seminal essay on Einstein[23] bears the following epigraph by William Blake:

> The Child's Toys and the Old Man's Reasons
> Are the Fruits of the Two Seasons.[24]

There is some evidence of Einstein's youthful interest in patient play with toys that involved delicate, hands-on construction; and of his mastery of how new-fangled technical devices, such as the telephone, worked. His sister Maja reports that, before the age of ten, his games—which were 'very indicative of his natural aptitudes'—included 'work with the fret-saw and the erection of complicated structures with the well-known "*Anker*" building sets, but best of all the construction of many-storied houses of cards.'[25]

A fellow student at the Luitpold Gymnasium, the prestigious Munich secondary school he attended, recalled Einstein explaining to him the principles of the telephone. And no wonder. While he was growing up his uncle Jakob, a trained engineer, and Einstein's father Hermann, a business man, were partners in the first Munich electrical engineering firm. Jakob had dabbled (unsuccessfully) in marketing an early model of the telephone and, at a time when they were still scarce, there was one in the Einsteins' Munich home; so one may surmise that his knowledge of its workings was acquired by 'hands on' methods. A few years later, Uncle Jakob remarked to one of the workmen in his factory:

> Do you know, it is really fabulous with my nephew. Whereas my assistant engineer and I broke our heads a whole day long [on a technical problem], the young lad worked out the whole story in a mere quarter of an hour. Something more will come of him![26]

[22] Erik H. Erikson, 'Einstein's Puzzles', in *Toys and Reasons* (New York, 1977). Peter Carruthers discusses 'Human Creativity: its cognitive basis, its evolution and its connections with childhood pretence' (*British Journal for the Philosophy of Science*, 53 (2002), 225–49) without mentioning either Freud or Erikson.

[23] In his essay, Erikson—following the lead of Gerald Holton, draws attention to the significance of *Anschauung* (visual imagery) in Einstein's mode of thought as child and adult, a topic discussed below.

[24] From 'Auguries of Innocence'.

[25] Maja Winteler-Einstein, 'Albert Einstein—Beitrag für sein Lebensbild [hereafter cited as 'Beitrag'], cited from John Stachel *et al.* (eds.), *The Collected Papers of Albert Einstein* (Princeton) [hereafter cited as *Collected Papers*], vol. 1 (1987), p. lix.

[26] Otto Neustätter, letter to Albert Einstein, 12 Mar. 1928. Translation cited from John Stachel, 'Introduction to the Centenary Edition' [hereafter cited as 'Introduction'] in John Stachel (ed.), *Einstein's Miraculous Year: Five Papers That Changed the Face of Physics* (Princeton, 2005) [hereafter cited as *Einstein's Miraculous Year*], p. xxx.

Einstein's first (1905) relativity paper shows that he was familiar with the then still-intense debate among physicists about the nature of unipolar induction,[27] a debate closely connected with practical engineering problems of electric dynamos,[28] the design and construction of which had been a major activity of the Einstein firm. Uncle Jakob actually held patents on a dynamo design; so again it is a fair surmise that young Albert first learned about the debate in its engineering context. In an authorised biography of Einstein, his son-in-law Rudolf Kayser wrote: 'As a result of his father's calling and his own mathematical ability, the position of technician and engineer was the first to be thought of [for Einstein].'[29] A letter written in 1918 confirms this:[30] 'I was also originally supposed to be a technical worker. But the thought of having to expend my inventive power on things, which would only make workaday life more complicated with the goal of dreary oppression by capital, was unbearable to me.'[31] Let us play out for a moment what might have happened to someone endowed with strong visual and tactile mental faculties (more about this later) that, in his family milieu, were easily channelled into an inclination towards technology, if—instead of failing—the family business had prospered and grown into a major force in the German electrical industry. Instead of the burden of debts his father left behind, suppose Einstein had faced the prospect of inheriting a vast and growing technical-industrial empire. Was it foreordained that, like Jesus in the Wilderness, he would reject all worldly temptations in favour of the pursuit of pure science?

[27] Albert Einstein, 'Zur Elektrodynamik bewegter Körper', *Annalen der Physik*, 17 (1905), 891–921, cited from the reproduction in *Collected Papers*, 2 (1989), 276–306. Unipolar induction is mentioned on p. 295, in which it is shown that the problem disappears in the relativistic framework.

[28] See Arthur I. Miller, 'Unipolar Induction: A Case Study of the Interaction between Science and Technology', *Annals of Science*, 38 (1981), 155–89, reprinted in *idem*, *Frontiers of Physics: 1900–1911: Selected Essays* (Boston, Basel, Stuttgart, 1986), pp. 153–89.

[29] Published only in English under the pseudonym Anton Reiser [Rudolf Kayser], *Albert Einstein: A Biographical Portrait* (New York, 1930), p. 42.

[30] 'Ich sollte ursprünglich auch Techniker werden. Aber das Gedanke, die Erfindungskraft auf Dinge verwenden zu sollen, welche das werktägliche Leben noch raffinierter machen, mit dem Ziel öder Kapitalschinderei, war mir unerträglich.' Albert Einstein to Heinrich Zangger, before 11 Aug. 1918, *Collected Papers*, 8B (1998), 850.

[31] Translation from 'New Introduction' to *Einstein's Miraculous Year*, p. xxxiii. Kayser adds: 'The choice of profession, however, had other implications: it made necessary a relationship with society and with a mechanical life constantly controlled by end-in-view and utilitarian purposes. Nothing seemed more frightful to young Albert Einstein. Moreover he was not ambitious: he wanted neither fame nor success. These mundane ideas were repugnant to him' (Resier [Kayser] *Albert Einstein*, p. 42).

The case of Walther Rathenau, who confronted just such a life-situation as I have described, suggests that it was not foreordained.[32] Scion of Emil Rathenau, who rose from obscurity to preside over the giant German electrical firm, the *AEG,* Walther also came from a middle-class Jewish background. He too combined a technical bent with a profound intellectual curiosity, and after Einstein moved to Berlin the two became good friends, sharing many intellectual interests and social concerns.

A decade older than Einstein, Rathenau had studied chemistry, physics and philosophy, culminating in a thesis on 'The Absorption of Light by Metals'. Going into the family business, he went on to become industrial czar of Germany during the First World War and then Foreign Minister during the Weimar Republic—a reminder that it was quite possible in early twentieth-century Germany to combine a career at the centre of power with a profound inner intellectual and spiritual life.[33] His career was cut short in 1922 by an assassin's machine gun, part of a wave of anti-Semitic attacks that led to serious concern for Einstein's life, a foretaste of what was in store for all of Germany a decade later.

Rather than regarding it as the external unfolding of some pre-existing inner pattern of development (I call this viewpoint 'the homunculus theory of personality'), I suggest we view the adolescent Einstein's turn away from his expected career in commerce[34] as a reaction to what he had seen first as excessive greed, and then inability to accept financial failure,[35] do to his family: his father, whose health deteriorated

[32] For a biographical study by Count Kessler, who knew both Rathenau and Einstein, see Harry Kessler, *Walther Rathenau: His Life and Work* (New York, 1969).

[33] 'The British politician Robert Boothby wrote of him: "He was something that only a German Jew could simultaneously be: a prophet, a philosopher, a mystic, a writer, a statesman, an industrial magnate of the highest and greatest order, and the pioneer of what has become known as "industrial rationalization"' (*Wikipedia* article 'Walther Rathenau').

[34] A turn that was more gradual than he depicted it in retrospect, and less complete: he did take out a number of patents over his lifetime, on at least one of which he collected royalties, and served as a technical expert witness in several financially important cases involving patent infringements.

[35] Maja Einstein wrote:

> Not only were the assets of Albert Einstein's mother lost at this time, but significant contributions from relatives as well. The family had hardly anything left. . . . In contrast [to uncle Jakob], Albert Einstein's father could not bring himself to take the same step [becoming an employee] and relinquish his professional independence. In particular, he did not want to bring suffering on his wife, who would have had great difficulty in accommodating herself to a lower standing in the social scale. Against the perceptive advice of his still quite young son, he founded a third electrical firm in Milan. ('Beitrag', translation cited from 'New Introduction' to *Einstein's Miraculous Year*, pp. xxviii–xxix).

rapidly under the influence of these blows, died in debt in 1902 at the age of 55; and his mother, brought up in wealth and used to servants, was left penniless and forced to take work as a housekeeper.

One possible reaction to the suggestion that, had circumstances been different, Einstein might have pursued a practical career is that of Helen Dukas. His secretary and later housekeeper for over twenty-five years, and the keeper of his flame for another quarter century after his death, she recounted her reply to an Einstein scholar who dared to suggest the crucial role of some external influences on his life: 'If Professor Einstein had been born at the North Pole and grown up among the polar bears, he still would have been Professor Einstein!' Some may laugh at these words, but still regard such external factors as at most exerting a facilitating or hindering influence on the unfolding of a creative talent such as Einstein's. This raises the question: 'What is creativity?'

The Transformative Question and the Question of Transformational Creativity[36]

But is this the right question to ask? As Eugene Ionescu observed, 'It is not the answer that enlightens, but the question.' Mihalyi Czikszentmihalyi has suggested that, rather than '*What* is creativity?' one should ask '*Where* is Creativity?' [37] First of all, he distinguishes between 'creativity with a small "c"' and 'creativity with a big "C"'.

> The definition that most people usually agree on is that creativity is a new idea or product which is socially acceptable, and which is brought to fruition. That's creativity with a big 'C', creativity that changes the culture. Then we can talk also about creativity which is a more personal experience, which affects the way one experiences life, with originality, openness, and freshness. That is something different, though the two overlap. Creativity with a small 'c', the personal creativity, is what makes life enjoyable, but it does not necessarily result in renown or success.

[36] From this point on I shall eschew use of 'genius' in favour of a discussion of 'transformational creativity'.

[37] Mihalyi Czikszentmihalyi, *Creativity: Flow in the Psychology of Discovery and Invention* (New York, 1996). See also *idem*, 'Society, culture, and person: a systems view of creativity', in Robert J. Sternberg (ed.), *The Nature of Creativity: Contemporary Psychological Perspectives* (New York, 1988).

With Einstein, we are dealing with 'creativity with a big "C"', which Czikszentmihalyi also calls 'transformational creativity'; so that is what we must analyse; and from now on the term 'creativity' will be used in this sense. Elsewhere, Czikszentmihalyi offered this short definition: 'Creativity is a new idea or product [of the individual], which is socially acceptable [to the field] and which is brought to fruition [in the domain]'. He distinguishes three elements that are involved in any creative process:

1 The Domain: e.g., mathematics or biology 'consists of a set of symbols, rules and procedures'.

2 The Field: 'the individuals who act as gatekeepers to the domain . . . [they] decide whether a new idea, performance, or product should be included'.

3 The Individual: creativity is 'when a person . . . has a new idea or sees a new pattern, and when this novelty is selected by the appropriate field for inclusion in the relevant domain.'[38] (Fig. 4.)

The psychologist Howard Gardner, who has done so much to popularise and develop Czikszentmihalyi's approach, emphasises:

> In Czikszenmihalyi's persuasive account, creativity does not inhere in any single node, nor, indeed, in any pair of nodes. Rather, creativity is best viewed as a dialectical or interactive process, in which all three of these elements participate.[39]

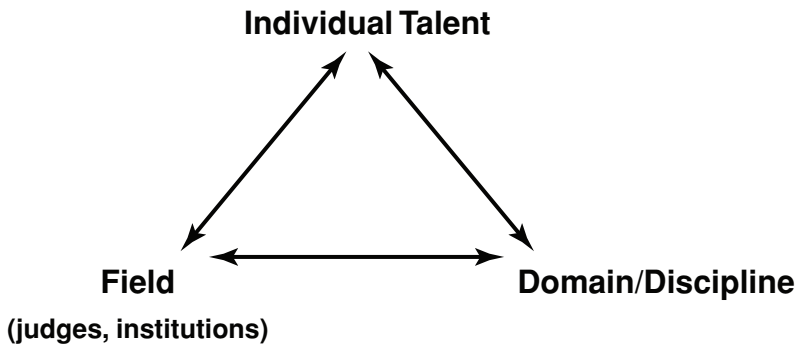


Figure 4. Mihalyi Czikszentmihalyi's triangle.

[38] 'The Well of Creativity', a conversation with Mihalyi Czikszentmihalyi by Michael Toms [hereafter cited as 'Toms Interview'], <www.newdimensions.org/online-journal/ articles/well-of-creativity.html>.
[39] Howard Gardner, *Creating Minds* (New York, 1993), p. 38.

So a discussion of transformational creativity takes one beyond the Individual to a consideration of the Domain and the Field. But I shall begin with the Individual.

Complexity of the Personality: Polarities

When asked, 'is there a creative personality with recognisable characteristics?', Czikszentmihalyi answered:

> People who are able to transform the domain in which they work do have certain similarities in the way their personality is put together. I call this the complexity of the personality.
>
> Each of us has several possible options for personality. We can either be extroverted and enjoy people but then feel a bit anxious when we are alone, or we can be introverted, which means that we like solitude but can't handle people. We are either masculine or feminine,[40] or cooperative or competitive, *et cetera*.
>
> Creative people, however, have the ability to use the full range of these separate dimensions, so that they have, for example, both masculine and feminine traits—both men and women have some of the strengths of the opposite gender. [41] They can be introverted when they have to be. When they have to work, they love being alone and working. But they also love being with people when that helps their work, so that they can get information, to know what other people are thinking and doing. The complexity of personality, that ability to unite the parts of the opposite traits of what normally are polarized personality traits, is common in creative people. . . .
>
> [T]hey are playful and responsible at the same time. The popular wisdom about these people is that they are very rebellious and iconoclastic; they like to break the rules; they like to break tradition. And that's true. But on the other hand, they are also very traditional, because they know that they are standing on the shoulders of giants, as Newton said. Whatever they accomplish is based on the accomplishments of previous generations. They take very seriously those accomplishments, and at the same time they are willing to go beyond and break the limits of what has been done or known in the past. All of these polarities are somehow integrated in their work.[42]

[40] I can make sense of theses words only if they are taken in the sense of a distinction of gender (which is socially constructed) rather than of sex (which is biologically determined).
[41] I would also purge this account of its sexist overtones.
[42] 'Toms Interview'.

This list of inseparable, opposing, but complementary traits consists of examples of what, following Karl Marx, I call *polarities* (Fig. 5).[43]

Elsewhere,[44] following the lead of Gerald Holton,[45] I have discussed some striking polarities characterising the development of Einstein's personality that are closely related to items on Czikszentmihalyi's list. Here I shall simply mention three of them:

1 His striving for recognition and approval from elders in positions of authority versus his need to maintain his independence of, and sometimes even to show defiance of, such authority figures,[46] in order to pursue his own goals. No better example of this youthful polarity can be found than a letter to his fiancée, written in 1901 when he was jobless. Having found what he thought to be some errors in an article by Paul Drude, an eminent physicist whose work Einstein valued highly, he wrote to Drude eagerly, hoping to establish contact with him and perhaps

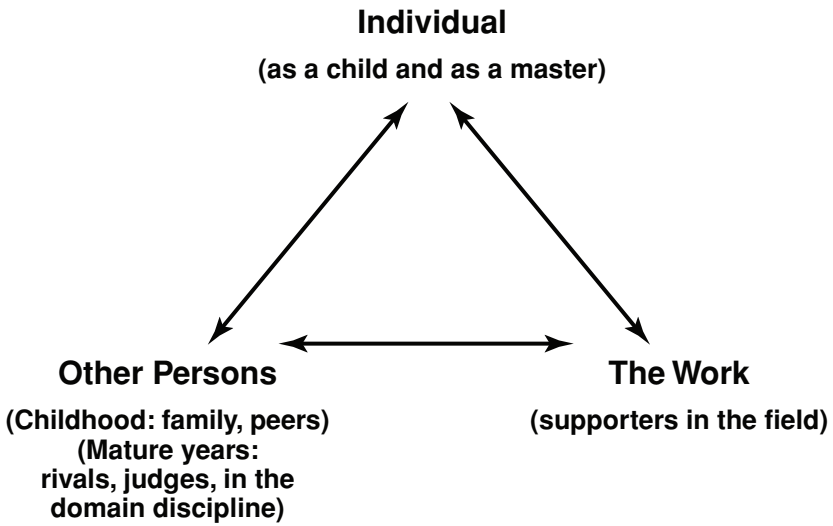


Figure 5. Howard Gardner's elucidation of Czikszentmihalyi's Triangle.

[43] In contradistinction to Czikszentmihalyi's usage, it is inherent in such polarities that both poles be present and interact dynamically. See John Stachel, 'The Concept of Polar Opposition in Marx's *Capital*', to appear in *idem*, *Going Critical*, vol. 2, *The Practice of Marxism*.

[44] John Stachel, 'New Introduction' to *Einstein's Miraculous Year, Centenary Edition*.

[45] Gerald Holton, 'On Trying to Understand Scientific Genius', in *idem*, *Thematic Origins of Scientific Thought*, rev. edn. (Cambridge, MA, 1988), pp. 371–98.

[46] 'Long live impudence! It is my guardian angel in this world!' Albert Einstein to Mileva Marić, 12 Dec. 1901 (*Collected Papers*, 1. 323).

obtain his help in finding an academic position, which Einstein needed desperately. But Drude's reply dashed his hopes as he told Marić:

> I just got home . . . and found this letter from Drude. It is such manifest proof of the wretchedness of its author that no further comment by me is necessary. From now on I'll no longer turn to such people, and will instead attack them mercilessly in the journals, as they deserve. No wonder little by little one becomes a misanthrope.[47]

Fortunately (for him), he never carried out this threat, and later on Drude was one of the first physicists to acknowledge Einstein's work on relativity.

2 His longing for close companionship and an intimate human relationship versus his need for solitude.[48] As we shall see below, he needed solitude to develop his intellectual 'inventions': the first stage of his thought process, being entirely non-verbal, required solitude; while the second stage, involving translation of the results of the first stage into words, depended on communication with others.

3 His attraction by the technical side of the family electrical engineering business, to which he even contributed from time to time, versus his repulsion by its commercial aspects, which had led to continual disappointment of his father's hopes for success and finally just for financial independence.

Erikson has discussed the defiant element in Einstein's personality and how it served him well in the course of his education:

> Were the boy's symptoms [beginning with his comparatively late start in speech] due to an outright *defect* or to a systematic *difference* in development; or were they also reinforced by a mighty *diffidence*—or, eventually, even some *defiance*? . . . [L]ittle Albert had it in him to object to having to learn anything in any but his own way. In his early childhood this could be expressed in a sudden rage (against a private teacher, for example) that was attributed to a disposition inherited from his maternal grandfather. Later, the resistance against enforced instruction, far from ever being 'broken', became a deep and basic character trait that permitted the child and the youth to remain free in learning, no matter how slowly or by what sensory or cognitive steps he accomplished it. (pp. 152–3)[49]

[47] Albert Einstein to Mileva Marić, 7? July 1901 (*Collected Papers*, 1. 308).

[48] 'I seek solitude, only then silently to lament it', Albert Einstein to Pauline ('Mama') Winteler, 21 May 1897 (*Collected Papers*, 5 [1993]. 3).

[49] 'Psychoanalytic Reflections on Einstein's Centenary', in Gerald Holton and Yehuda Elkana (eds.), *Albert Einstein: Historical and Cultural Perspectives* (Princeton, 1982), pp. 151–73.

The dialectical interplay of individual, others, and work

Czikszentmihalyi was asked, 'We have the myth of single individual out there being creative, but there's something else involved, right?' He replied:

> Yes, luck was the most often-mentioned reason for successful creativity that these creative and well known people gave—people like Jonas Salk . . . and Linus Pauling, who won two Nobel prizes. . . By that they meant several things. They meant, as Pauling said, good genes are luck. Having a background that allows you to focus on a particular domain of knowledge, that is partly luck. Being in the right time and right place is luck. . . . In many ways luck does play a big role in transforming creativity with a small 'c' into creativity with a capital 'C'.[50]

So one must pass beyond the individual, to what Gardner called the 'dialectical or interactive process', between an Individual, others in the Field and the work contributed to the Domain. First of all, one must learn to relate individual and social psychology.

If I may be permitted a personal note, sixty years ago, I took Gardner Murphy's course on 'The Theory of Personality'.[51] From him I learned the concept of the *canalisation* of human drives:[52] that the individual, biological aspects of these drives cannot be separated from their culturally shaped expression in the developing personality. This approach helped me avoid the then common—and still not uncommon—discussion of human behaviour in terms of innate human instincts,[53] which are either facilitated or inhibited by society,[54] an approach leading to the still familiar dilemma of nature versus nurture with its deterministic overtones.

[50] 'Toms Interview' (see above, n. 38).

[51] See Gardner Murphy, *Personality: A Biosocial Approach to Origins and Structure* (New York and London, 1947), 2nd edn. (New York, 1966).

[52] Murphy pointed out that the term 'canalisation' was introduced by the nineteenth-century French psychologist Pierre Janet.

[53] It is still popular among evolutionary psychologists: 'what is special about the human mind is not that it gave up "instinct" in order to become more flexible, but that it proliferated "instincts"—that is content-specific problem-solving specializations' (J. Tooby and L. Cosmides, 'The psychological foundations of culture', in J. H. Barkow *et al*. (eds.), *The Adapted Mind* (New York, 1992), pp. 19–136. I shall present a critique of evolutionary psychology in the last section.

[54] My reading of the then practically unknown Erik Homberger Erikson, in particular 'Problems of infancy and early childhood', in *Encyclopedia of Medicine, Surgery and Specialties* (Philadelphia, 1940), pp. 714–30, also helped me to see the possibility of a less strict interpretation of Freud than orthodox psychoanalysis provided. In 1979 I was privileged to meet Erikson and discuss Einstein with him at length.

Gardner Murphy, then a renowned social psychologist, appears to have been forgotten,[55] but his biosocial approach to personality is alive and well today—perhaps more so than it was when I was a student. Witness for example, the work of Jaan Valsiner, who warns that 'The glory of the person becomes a myth that overrides the person's linkages with the social world',[56] a danger that one must be especially on guard against in approaching Einstein. This is so not only because of the aura of popular myths that surrounds his name, but because of the need to re-examine many scholarly myths about Einstein in the light of the dialectic between individual talent, domain and discipline.[57]

Einstein himself started spreading such myths even as he was shaping himself as an adolescent. In 1897, aged 18, he wrote to Pauline 'Mama' Winteler,[58] declining an invitation to spend the Easter holidays with the Winteler family:

> It would be more than shameful if I were to buy a couple of days of pleasure at the price of the pain, much too much of which I have already caused the dear child through my fault. It fills me with a sort of strange satisfaction to have to experience now a part of the pain that my thoughtlessness and ignorance have caused such a delicate nature as that of the dear girl. Strenuous intellectual work and the contemplation of God-given Nature are the angels that will guide me—reconciled, fortified, and yet inexorably strong—through all the turmoil of this life. . . . One thus creates for himself a small world—however pitifully insignificant it may be compared to the eternally changing greatness of true existence—and yet feels wonder himself at how great and important it is, just like for example the mole in the hole that he has excavated for himself.[59]

This credo simultaneously reveals and conceals a great deal about himself. It is interesting to compare this statement, evidently written in large part as self-justification for his emotional withdrawal from a youthful affair, with another that he wrote twenty years later as a mature scientist:

[55] I take this opportunity to belatedly acknowledge that taking his course was an unforgettable experience.

[56] See Jaan Valsiner, *The Guided Mind: A Sociogenetic Aproach to Personality* (Cambridge, MA, 1998), p. 1; see also Jaan Valsiner and René van der Veer, *The Social Mind: Construction of an Idea* (Cambridge, 2000).

[57] I do not exempt my own work from this stricture.

[58] She was the wife of Jost Winteler, a teacher at the Aargau Kantonsschule. Einstein boarded with the Winteler family while attending the school and grew quite fond of 'Papa' and 'Mama' Winteler. He had a brief but apparently chaste affair with Marie, one of the Winteler daughters.

[59] Albert Einstein to Pauline Winteler, May 1897, *Collected Papers*, 1. 55–6.

> [O]ne of the strongest motives that leads to art and science is escape from everyday life with its painful crudity and bleak aridity, from the fetters of ever-changing personal desires. . . . Each human being tries to make for himself in the fashion that suits him best a simplified and intelligible picture [*Bild*] of the world and thus to overcome the world of experience, by trying to some extent to substitute for it this picture of his own. . . . He displaces the center of gravity of his emotional life to this picture and its shaping in order to seek the repose and solidity that he cannot find in the all-too-narrow sphere of the maelstrom of personal experience.[60]

Erik Erikson, after discussing the child's development of 'the rudiments of sense of guilt' and 'the awareness of some sinful curiosity', goes on:

> I shall not, and could not, specify the fate of such early conflicts in Einstein's childhood. I can only conclude that when he made the statement of his turn from 'I' and 'We' to 'It', he was aware of some of the interpersonal conflicts that he thus learned to avoid and yet also to sublimate in his concentration on the phenomenal.[61]

Nor shall I pursue this topic any further, except to remark that the emotional detachment, with which the older Einstein increasingly portrayed the younger—no doubt in all sincerity—was the terminus and not a starting point of his development.

Creation, discovery, or invention?

Before going further, let us pause to consider the proper word to characterise Einstein's individual contribution to the process of scientific creativity. He preferred 'invention',[62] and I think 'invention' is a good choice. I suggest that three words—creation, discovery and invention—as applied to individuals be used to describe different processes. These

[60] Albert Einstein, 'Motive des Forschens' ['Motives for Research'], speech given in 1918 at a meeting in honor of Max Planck's sixtieth birthday, *Collected Papers*, 7 (2002), 55–8. English translation: 'Principles of Research', in Albert Einstein, *Ideas and Opinions* (New York, 1954), p. 225; the translation has been modified.

[61] 'Psychoanalytic Reflections on Einstein's Centenary', in Gerald Holton and Yehuda Elkana (eds.), *Albert Einstein: Historical and Cultural Perspectives* (Princeton, 1982), p. 152.

[62] See his comments on this question in Alexander Moszkowski, *Einstein: Einbicke in seine Gedankenwelt* (Hamburg and Berlin, 1921). Einstein once wrote about the philosopher Ernst Mach: 'Mach's weakness [was that he thought] theories . . . arise [from] discovery and not [from] invention.'

processes are distinguished by two factors: the source of the goal of the process and the source of the constraints on it (Fig. 6).

Creation, as in the phrase 'Lev Tolstoi created Anna Karenina', combines an internally set goal with internal constraints. The urge to portray a certain woman in a certain social milieu and how this milieu ultimately drove her to suicide came from no external compulsion. And (however much advice he may have received) the judgements about how to go about writing her story and when he had finished were ultimately his own. The term creation seems generally more appropriate in the arts than in the sciences.

Discovery, as in the phrase 'Columbus discovered the West Indies' (for white Europeans, I hasten to add), combines an externally set goal with external constraints on it. The goal of Columbus was to reach the East Indies, but a rather large external constraint—the Americas—prevented him from reaching that goal, and so he reached the West Indies instead. The term discovery seems to fit much experimental work in science,[63] and perhaps even some theoretical work; but hardly the kind of grand theoretical enterprises that characterised Einstein's life work (discussed below).

Invention, as in 'Einstein invented general relativity', combines the right mixture of internally set goals and externally imposed constraints. In 1907, Einstein set out to include gravitation within the scope of the 1905 theory of relativity (which we now call 'special relativity'), but an external constraint on his search—the equality of gravitational and inertial mass—soon led him to conclude that he would have to pass beyond

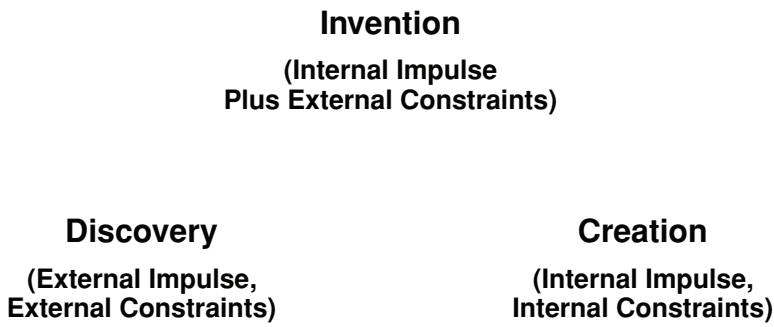


Figure 6. Invention, Discovery and Creation.

[63] As in 'The Curies discovered radium', or 'Pluto was discovered by Lowell' (I do not want to get into controversies about who discovered Neptune).

the special theory to reach his goal. And another external constraint—the challenge of explaining the anomalous motion of the perihelion of Mercury—drove him onwards until his final triumph in November 1915. The term invention seems to well characterise the level at which a Newton, a Darwin, a Freud, operated, to mention only other scientists treated in Master-Mind lectures.[64]

Einstein's inventiveness

We can learn a great deal about Einstein from his younger collaborators and assistants, several of whom I shall cite. Peter Bergmann, his assistant from 1936 to 1941, recalled:

> [W]hat impressed me most after I had gotten to know Einstein and his style . . . was his tremendous persistence. Once having perceived the really important problems, he would not let go. He might let go temporarily if a road seemed to be completely blocked, but he would pick up the problem again a few weeks later—in the meantime having worked on another, equally interesting problem.[65]

Elsewhere Bergmann reminisced:

> A second thing that impressed me—and remember that I was very young and that Einstein was in his late fifties—was his tremendous creativity, even on the small, day-to-day difficulties, his sheer inventiveness of new approaches, of new mathematical tricks. I think what made Einstein extraordinary (a common characteristic is that many creative persons are very uncritical toward their own ideas; they may be critical toward the ideas of others) was that he could work up tremendous enthusiasm for a new unitary field theory—and during the five years I was in Princeton certainly there was a large number of new unitary field theories—but there would always come the moment of truth. Einstein would discover the fatal flaw in what he himself had initiated and ruthlessly cut off that attempt, only to take on a new idea for work usually within a few days.[66]

Early in his career, Einstein was aware of his ability to single out significant problems in physics:

[64] I shall 'bracket' the question of Eratosthenes and the nature of mathematics. Clearly a Platonist and a constructivist will differ completely on how to characterise mathematical research.

[65] 'Reminiscences', in Holton and Elkana (eds.), *Albert Einstein*, p. 398.

[66] 'Working with Einstein', in Harry Woolf (ed.), *Some Strangeness in the Proportion: A Centennial Symposium to Celebrate the Achievements of Albert Einstein* (Reading, MA, 1980), p. 479.

> The fact that I neglected mathematics to a certain extent had its cause not merely in my stronger interest in the natural sciences . . . but also in the following peculiar [*eigentümlich*] experience. I saw that mathematics was split into numerous specialties, each of which could absorb the short lifetime granted to us . . . [M]y intuition was not strong enough in the field of mathematics to differentiate clearly the fundamentally important . . . from the rest of the more or less dispensable erudition . . . [P]hysics also was divided into separate fields, each of which was capable of devouring a short lifetime of work without having satisfied the hunger for deeper knowledge. The mass of insufficiently connected experimental data was overwhelming here also. *In this field, however, I soon learned to scent out that which might lead to fundamentals, and turn aside from everything else*, from the multitude of things that clutter up the mind and divert it from the essentials.[67]

Ernst Straus, Einstein's next assistant, cited Goethe's *Faust* to describe Einstein's goal.[68] Einstein revered Goethe as one of the rare creative figures at the highest level: 'It is only men who are free, who create the inventions and intellectual works which to us moderns make life worthwhile.'[69] And with Faust, we return to the Magus *par excellence* of Western European civilisation—the man who sold his soul to the devil for knowledge of and power over the universe (Fig. 7). Einstein once commented to the novelist Hermann Broch about Broch's novel *Virgil*: 'The book shows me clearly what I fled from when I devoted myself body and soul to science—the flight from the I and from the We to the It.'[70] And since becoming associated with the development of the atomic bomb (for whatever good or bad reasons), the mythic Einstein of the popular imagination has taken on much of the moral ambiguity of the mythic Faust.

Returning to Straus, he cites two passages from *Faust* for aptness in characterising Einstein. The first passage he cites reads:

> *um zu verstehen was die Welt*
> *in Innersten zusammen hält.*

[67] Albert Einstein, 'Autobiographical Notes' (1949), cited from *idem*, *Autobiographical Notes* (LaSalle, IL, 1979), pp. 15 and 17, emphasis added.
[68] 'Working with Einstein', in Harry Woolf (ed.), *Some Strangeness in the Proportion*, p. 482.
[69] Albert Einstein, 'Science and Civilization' in *Out of My Later Years* (Secaucus, NJ, 1956), pp. 148–51.
[70] 'Es zeigt mir das Buch deutlich, vor was ich geflohen bin, als ich mich mit Haut und Haar der Wissenschaft verschrieb: Flucht vom Ich und vom Wir in das Es', Albert Einstein to Hermann Broch, 1945, cited from Banesh Hoffmann and Helen Dukas, *Albert Einstein Creator and Rebel* (New York, 1972), p. 254. German text cited from the German edition, *Einstein: Schöpfer und Rebell Die Biographie* (Zürich 1976), p. 298.

Figure 7. Rembrandt, *Faust*, *c*.1652. © Rijksmuseum, Amsterdam.

Straus's translation of this text is 'to understand what holds the world together at its core'. But the text he cites is incorrect! In all versions of *Faust*,[71] it actually reads:

> *Daß ich erkenne, was die Welt*
> *Im Innersten zusammen hält*

[71] That is, *Urfaust, Faust Ein Fragment*, and the final version. Both this and the following quotation are from 'Nacht', the first scene of the drama.

Erkennen is more intuitive than *verstehen*, so the translation should run something like:

> That I recognise what holds the world
> together in its innermost parts.

This is reminiscent of Einstein's words: 'Invention appears here as a constructive activity. So what constitutes the originality of the matter essentially does not consist of this . . . The really valuable thing is basically intuition.'[72] Going back to the correct passage from *Faust* and considering its applicability to Einstein, it continues in a quite striking way:

> *Schau alle Wirkenskraft und Samen,*[73]
> *Und tu nicht mehr in Worten kramen*
>
> Behold all active forces and seminal elements,
> And stop rummaging about with words.

As will soon be seen, Einstein reported that his primary thinking process did not involve 'rummaging about with words', bur rather with visual and tactile images.

Straus cites a second passage from *Faust* as follows:

> *und was sie [Natur] deinem Geist nicht offenbart,*
> *das zwingst du ihr nicht ab mit Hebel und Schrauben*
>
> and what she [nature] won't reveal to your spirit,
> you won't force from her with levers and screws.
> (Straus's translation)

Again, this passage is not accurately cited. The full, correct German text reads

> *Läßt sich Natur des Schleiers nicht berauben,*
> *Und was sie deinem Geist nicht offenbaren mag,*
> *Das zwingst du ihr nicht ab mit Hebeln und mit Schrauben.*
>
> Do not rob nature of her veils,
> And what she does not want to reveal to your spirit
> You cannot force from her with levers and with screws.

[72] 'Das Erfinden tritt hier als eine konstruierende Tätigkeit auf. Hierin also liegt nicht das, was die Originalität der Sache im wesentlichen ausmacht . . . das eigentlich Wertvolle ist im Grunde die Intuition.' Reported in Alexander Moszkowski, *Einstein: Einbicke in seine Gedankenwelt* (Hamburg and Berlin, 1921), p. 111.

[73] Samen, literally 'semen' or 'seeds', is an alchemical term for 'the primordial substances . . . out of which all things have grown' (*Goethe's Faust—Part I*, ed. Calvin Thomas (Boston, 1892), p. 256).

I have presented both Straus's and Goethe's versions because the obvious difference between them leads straight to Einstein's view of the difference between Art and Science. After stating what they have in common: 'When the world ceases to be the scene of our personal hopes and wishes, where we face it as free beings admiring, asking, and observing, there we enter the realm of Art and Science', he states the distinction:

> If what is seen and experienced is portrayed in the language of logic, we are engaged in science. If it is communicated through forms whose connections are not accessible to the conscious mind but are recognized intuitively as meaningful, then we are engaged in art.

Finally, he returns to the common theme: 'Common to both is the loving devotion to that which transcends personal concerns and volition.'[74] So, in the Sciences, Einstein evidently sides with Straus's version of the text. In the Arts (here we finally come to Music), Einstein sides rather with Goethe's original: 'This is what I have to say about Bach's life work: listen, play, love, revere—and keep your trap shut!' [*das Maul halten!*] 'As to Schubert, I have only this to say: play the music, love—and shut your trap' [*Maulhalten*].[75]

Now I shall 'shut my trap' about the arts and return to science.

Banesh Hoffmann, an Einstein collaborator from the 1930s, reports Einstein's view of scientific theories:

> I asked him once about a theory, and he said, 'When I am evaluating a theory, I ask myself, if I were God, would I have made the universe that way.' If the theory did not have the sort of simple beauty that would be demanded of a God, then the theory was at best only provisional.[76]

Einstein on his 'proper life's work'

What were the 'really important problems,' that 'inner core' for which Einstein was searching? In 1932 he wrote:

> The goal of my research has always been the simplification and unification of the system of theoretical physics. I attained this goal satisfactorily for macroscopic phenomena, but not for the phenomena of quanta and atomic structure. I believe that, despite considerable success, the modern quantum theory is also still far from a satisfactory solution of the latter group of problems.[77]

[74] Albert Einstein, 'What Artistic and Scientific Experience Have in Common' (1921), cited from Helen Dukas and Banesh Hoffmann (eds.), *Albert Einstein: The Human Side* (Princeton 1979), pp. 37–8.
[75] Both citations are from *The Human Side*, p. 75.
[76] 'Working with Einstein', in Harry Woolf (ed.), *Some Strangeness in the Proportion*, p. 476.
[77] *The Human Side*, p. 12.

I do not believe that anything that happened in the remaining twenty-three years of his life would have led Einstein to modify these judgements. In the same year he wrote to a psychologist enquiring about the motivation of his scientific work:

> It was always the striving for a logically simple interpretation of empirically known connections, supported by the conviction of the existence of a logically simple interpretation.[78]

Einstein once listed three key questions that he had posed to himself in the course of his work in physics, the pursuit of which he characterised as follows: 'These three questions characterize my own proper life's work.' The first question was:

> How does the representation of a light ray depend on the state of motion of the coordinate system, with respect to which it is referred?

About ten years of work on this question led to the special theory of relativity. Einstein summarised this work as follows:

> I will give you as an example the situation that led to the setting up [*Aufstellung*] of the special theory of relativity. Mechanically all inertial systems are equivalent. Experience shows that this equivalence also extends to optics and electrodynamics. But this equivalence appeared unattainable in the theory of the latter. Early on I came to the conviction that this had its basis in a deep incompleteness of the theoretical system. The desire to discover and remove this generated a state of physical tension in me that was resolved after seven years of vain searching by the relativising of the concepts of time and length.[79]

The result, special relativity, is certainly an example of transformational creativity. And one may say that, in the main, its effects in transforming the domain of physics have been completed.[80]

The second key question was:

> What is the basis for the equality of the gravitational and inertial mass of bodies?

Work on this question for about eight years led to the general theory of relativity, after ninety years still the best theory of gravitation that we have. In this case, I do not believe that the transformational effects on the domain of physics have been completed. As I have discussed in detail else-

[78] Einstein to Erika Oppenheimer, 13 Sept. 1932. See Erika Fromm, 'Lost and Found Half a Century Later: Letters by Freud and Einstein', *American Psychologist*, 53 (1998), 1195–8.
[79] Ibid.
[80] I qualify this statement a bit, because many textbooks still present accounts of the special theory that are based more on Lorentz's pre-relativistic dynamical interpretation of the Lorentz transformations than on the kinematical interpretation of them that Einstein gave.

where,[81] all previous physical theories including the special theory, have been based on the existence of a fixed background space-time structure. General relativity is the first example of a totally background-free physical theory; in particular, the space-time structures are dynamical fields interacting with all other matter and fields in the universe. And the physics community (the Field) is still struggling with the implications of a background-free physics (see the discussion of quantum theory below for some additional remarks on this question).

The third key question was:

> Can the gravitational field and the electromagnetic field be grasped theoretically in a unified manner?

Einstein worked on the search for such a unified field theory for the last thirty years of his life, without bringing the work to a satisfactory conclusion. In particular, the major transformation of the domain of physics that he hoped to accomplish with a unified theory—the explanation of all quantum phenomena without the need to invoke the basic principles of quantum mechanics—has been abandoned by the community. Current work on a unified theory (often called a 'Theory of Everything' or TOE for short) is based on the need to apply some form of these quantum-mechanical principles.

After listing these three key questions, he added: 'Whatever else I occupied my mind with was more odd-job work ["*Gelegenheitsarbiet*"] . . . and is related to the current problems of physics.' By this he meant that his work on such topics as Brownian motion, the effects of suspended particles on fluid viscosity, etc., important as they were and still are, did not exert a transformative effect on the domain.

Remarkably, he omitted from his list of key questions (and thereby seemed to relegate to the status of '*Gelegenheitsarbeit*') any question about the nature of light. Yet in 1905, his *Annus Mirabilis*, he characterised his paper on light quanta (and only that paper) as 'revolutionary'. And near the end of his life, he signalled the importance of this question:

> The whole fifty years of conscious rumination ['*Grübelei*'] have not brought me nearer to the answer to the question 'What are light quanta?' Nowadays, every scalawag ['*Lump*'] believes that he knows what they are, but he deceives himself.

[81] 'The Development of the Concepts of Space, Time and Space-Time from Newton to Einstein', in Abhay Ashtekar (ed.), *One Hundred Years of Relativity* (Singapore, 2005), pp. 3–36.

So I feel justified in adding this question to Einstein's list.[82] In my words, rather than his, the fourth key question is:

> What is the nature of light—and matter—quanta?

The best current answers to this question are given by the quantum theory of fields, which is based on the fixed background space-time structure of the special theory. For this reason, and quite aside from his other problems with quantum mechanics, Einstein could never accept such answers as final. And indeed, until some synthesis of background-free general relativity and background-dependent quantum field theory is achieved, one cannot say that our current answers are complete. The search for such a synthesis is called the problem of quantum gravity. Elsewhere, I have commented on the significance of Einstein's work.[83]

The creative individual: domain specificity

These few comments on what uniquely characterised Einstein's life work raise the question of the nature of human intelligence. Piaget regarded all aspects of symbolic activity as elements of a unique 'semiotic function'. Howard Gardner disputes this, maintaining that:

> human cognition is multifaceted and that the human intellect is best thought of as an ensemble of relatively autonomous faculties—ones that I have dubbed the various 'human intelligences'.[84]
>
> Whereas Piaget . . . had conceptualized all aspects of symbol use as part of a single 'semiotic function', empirical evidence was accruing that the human mind may be quite modular in design. That is, separate psychological processes appear to be involved in dealing with linguistic, numerical, pictorial, gestural, and other kinds of symbolic systems. . . . Individuals may be precocious with one form of symbol use, without any necessary carry over to other forms. By the same token, one form of symbol use may become seriously compromised under conditions of brain damage, without correlative depreciation of other

[82] For further discussion of all four questions, see John Stachel, *Einstein From 'B' to 'Z'* (Boston, Basel and Berlin, 2002).

[83] John Stachel, 'Albert Einstein: A Man for the Millenium?', in Lysiane Mornas and Joaquìn Diaz Alonzo (eds.), *A Century of Relativity Physics: ERE 2005 XXVII Spanish Relativity Meeting: AIP Conference Proceedings*, vol. 841 (Melville, NY, 2006), pp. 195–227. Reprinted in Jean-Michel Alimi and André Füzfa (eds.), *Albert Einstein Century International Conference Paris, France 18–22 July 2005: AIP Conference Proceedings*, vol. 861 (Melville, NY, 2006), pp. 211–43.

[84] Gardner, *Creating Minds*, p. xii.

> symbolic capacities. . . . Indeed, different forms of symbol use appear to be subserved by different portions of the cerebral cortex.[85]

Note Gardner's use of the plural: 'intelligences'. Perhaps, at this stage of our understanding of the processes involved, it is safer to speak of *domain-specificity*: 'Cognitive abilities are domain-specific to the extent that the mode of reasoning, structure of knowledge, and mechanisms for acquiring knowledge differ in important ways across distinct content areas.'[86]

Susan Gelman points out:

> Domain-specificity is not a single, unified theory of the mind. There are at least three distinct approaches to cognition that assume domain specificity. These approaches include modules, theories, and expertise. . . .
>
> The most powerful domain-specific approach is modularity theory, according to which the mind consists of [citing Chomsky] 'separate systems [i.e., the language faculty, visual system, facial recognition module, etc.] with their own properties'.

Within this approach there is disagreement on 'whether modularity is restricted to perceptual processes or affects reasoning processes as well, and whether modularity is innate or constructed'. Proponents of the three approaches

> make different assumptions concerning what is innate, the role of input, mechanisms of development, interindividual variability in performance, and what constitutes a domain . . . Nevertheless, they converge on the proposal that cognitive abilities are specialized to handle specific types of information.[87]

Without going any further into these issues, one may already recognise the assertion 'that cognitive abilities are specialized to handle specific types of information' offers the potential for a much deeper understanding of such well-known facts about Einstein as his comparatively late development of speech, retention of a primarily aural relation to words throughout his life; and discomfort at penning them even while doing so to beautiful effect.

Here is Einstein's description of his reasoning process:

> Words or language, as they are written or spoken, do not seem to play any role in my mechanisms of thought. The psychical entities which seem to serve as

[85] Howard Gardner and Thomas Hatch, *Multiple Intelligences Go To School: Educational Implications of the Theory of Multiple Intelligences. CTE Technical Report*, Issue No. 4, March 1990, cited from <www.edc.org/CCT/ccthome/reports/tr4.html>.
[86] Susan A Gelman, 'Domain Specificity', cited from <www.psych.upenn.edu/courses/psych 172_Spring2003/domainspec.htm>.
[87] Ibid.

> elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined. . . . [T]he above mentioned elements in my case are of visual and some of muscular type. Conventional words or signs [he presumably had in mind mathematical symbols] have to be sought for laboriously only at a secondary stage . . . In a stage when words intervene at all, they are in my case purely auditory.[88]

As an example of how recent research may shed light on such a question, I cite an article from the 14 February 2005 online edition of *Nature*, entitled 'Different processes underpin the grammars of numbers and of language'. Study of three aphasia victims showed that they

> can understand 'grammatical rules' in mathematics even though they cannot handle analogous rules in language. . . . Although the patients were unable to decode such linguistic expressions [unable to differentiate the 'The boy chased the girl' from 'The girl chased the boy'], they were able to perform the mathematical calculations [such as $90-[(3+17)\times 3]$] accurately with pen and paper . . . The discovery challenges a commonly held view [by Chomsky, for example] that linguistic and mathematical mental processing draw on the same cognitive resources.

'Our findings very strongly turn that idea on its head', says Rosemary Varley, a cognitive neuroscientist at the University of Sheffield, UK. If this finding holds up, it sheds light on the compatibility of young Einstein's facile manipulation of algebraic and geometric problems at a time he was having difficulty learning French.

Stephen M. Kosslyn has begun the task of relating these advances in cognitive science to the question of Einstein's mode of thought:

> Perhaps the most striking advance of contemporary cognitive science and cognitive neuroscience is the differentiation of mental faculties. Virtually all faculties that we name with a single word, such as memory, language, perception and imagery, have turned out not to be a single 'thing' but rather, to have a complex underlying structure (p. 272). It turns out that Einstein probably would have been a good psychologist after all; as he reported . . . , images can be visual (with high or low resolution), spatial, or motoric (p. 282).[89]

[88] Albert Einstein, response to a questionnaire in Jacques Hadamard, *An Essay on The Psychology of Invention in the Mathematical Field* (Princeton, 1955); cited from its publication as 'A Mathematician's Mind', in Albert Einstein, *Ideas and Opinions* (New York, 1954), pp. 25–6.

[89] 'Einstein's Mental Images The Role of Visual, Spatial and Motoric Representations' [hereafter cited as 'Einstein's Mental Images'], in Albert M. Galaburda, Stephen M. Kosselyn and Yves Christen (eds), *The Languages of the Brain* (Cambridge, MA and London, 2002), pp. 271–87. I thank my colleague Fred Tauber for bringing this article to my attention.

Needed: a critique of cognitive science

Howard Gardner has opined that:

> Knowledge is accumulating at a phenomenal rate in both brain science and genetics. At the risk of seeming hyperbolic, I am prepared to defend the proposition that we have learned as much from 1983 to 2003 as we did in the previous 500 years.[90]

So the future of cognitive science looks bright. But in order to fulfill its destiny, I maintain that it must be subjected to a critique analogous to Marx's critique of classical political economy.[91] He pointed out that economists 'naturalize' certain social relations. For example, instead of understanding that capital is a social relation between people mediated by material objects, they regard any object used in production as capital, thus making the caveman with his flints and Bill Gates of Microsoft fellow capitalists.

Similarly, some cognitive scientists regard the brain as the source of behaviour, rather than as the material carrier of socially fashioned behavioural traits. By conjoining the insights of social psychology with those of cognitive science, we are reaching a point, at which it is becoming possible to flesh out Marx's brilliant *aperçu* that '[T]he human essence is no abstraction inherent in each single individual. In its reality it is the ensemble of the social relations.'[92] Aaron Cicourel has long argued the need for such a conjunction. In 1974, he insisted that:

> Social structure remains an accountable illusion of the sociologist's common sense knowledge unless we can reveal a connection between the cognitive processes that contribute to the emergence of contextual activities, and the normative accounting schemes we use for claiming knowledge as laymen and researchers.[93]

Ten years ago, he said:

> Social scientists tend to ignore the role of human information processing for the production of social interaction and more complex forms of social organization.

[90] 'Multiple Intelligences After Twenty Years' (2003) <pzweb.Harvard.edu/PIs/HG_MI_after_20_years.pdf>.

[91] For a discussion of Marx's viewpoint, see John Stachel, '"The Relations Between Things" versus "The Things Between Relations": The Deeper Meaning of the Hole Argument' in David Malament (ed.), *Reading Natural Philosophy: Essays in the History and Philosophy of Science and Mathematics* (LaSalle and Chicago, 2002), pp. 232–66.

[92] Karl Marx, 'Theses on Feurbach' (1843). English translation cited from Karl Marx, *Early Writings* (New York, 1975), p. 423.

[93] Aaaron V. Cicourel, 'Preface' to *Cognitive Sociology* (New York, 1974), p. 7.

> Cognitive scientists, however, tend to take for granted the influence and constraints that complex forms of social organization and locally-organized social interaction can have on information processing. . . . Work on the neurobiology of human cognitive processes tends to pay only lip service to 'experience' or the role of the local environment or social ecology on brain maturation.[94]

A recent review points out that:

> Although social scientists have developed a rich theoretical and methodological framework for examining and understanding social cognition, they have only recently begun to consider its neural substrates.[95]

On the other hand,

> Cognitive science often carries on as though humans had no culture, no significant variability and no history. . . . It is not an exaggeration to say that theories of cognitive structure are built mostly upon studies of the human mind as manifest in literate, postindustrial society and upon studies of the capabilities of computers.[96]

The Brazilian philosopher Marcos Barbosa de Oliveira has undertaken a critique of cognitive science, leading him

> to reject naturalism,[97] and in the course of this process I became aware—again with a certain surprise—that the conclusions, at which I was arriving, had a certain affinity with the Marxist dialectical tradition; or more exactly, in philosophy with the currents of Western Marxism, and in psychology with the school of Vygotsky and his followers.[98]

Such a critique is beginning to take shape within cognitive science itself. Kosslyn discusses the question of whether brain connections are hard-wired:

[94] Cicourel, 'Cognition and Cultural Belief', in Peter Baumgartner and Sabine Payr (eds). *Speaking Minds: Interviews with Twenty Eminent Cognitive Scientists* (Princeton, 1995), p. 50.
[95] David M. Amodio and Chris D. Frith, 'Meeting of minds: the medial frontal cortex and social cognition,' *Nature Reviews: Neuroscience*, 7 (2006), 268–77, at p. 268.
[96] Merlin Donald, *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition* (Cambridge, MA and London 1991), pp. 1 and 5.
[97] Elsewhere, he defines 'naturalism . . . as the methodological attitude in the human sciences that takes the natural sciences as the paradigm to follow. . . . The central thesis that I tried to establish, in contraposition to naturalism, is that there are essential differences between the natural sciences and the human sciences, so that the natural sciences cannot and should not be taken as a paradigm for the human sciences, or broadly construed, for the humanities in general' (Marcos Barbosa de Oliveira, Entrevista concedida aos Profs. Michael Wrigley e Maria Eunice Gonzales em 11 de junho de 1999).
[98] *Da Ciência Cognitiva à Dialética* (São Paulo, 1999), p. 10. I thank Dr Luciana Garbayo for help with the translations from the Portuguese.

> [Peter] Huttenlocher [*Neural Plasticity* (Cambridge, MA, 2002)] summarizes evidence that only a minority of brain circuits are defined by the genes; the rest are initially configured randomly, and only via experience are specific circuits formed. I am going a step further here, suggesting that in the adult brain at least some of these circuits are 'general purpose' and that the pattern of activity within them defines different modules in different circumstances (functionally, not structurally—the connections themselves are not changed, only the patterning within them). . . . [T]he current enthusiasm for 'evolutionary psychology' (for example Pinker [*How the Mind Works* (New York, 1997)]) relies on the idea that modules have been produced via natural selection. If many modules for higher-level cognitive functions are not predefined by the genes, then this story will require modification.[99]

David Buller asserts that: '[A]lthough an adult human brain can be characterized by "modular" information-processing structures, these are environmentally shaped, not "genetically specified" outcomes of development.'[100]

In an interview, Buller answered the question, 'Why do you say the evolutionary psychology paradigm is problematic?'

> There are three foundational claims that it makes. One is that the nature of [evolutionary] adaptation is going to create massive modularity in the mind—separate mental organs functionally specialized for separate tasks. Second, that those modules continue to be adapted to a hunter-gatherer way of life. And third, that these modules are universal and define a universal human nature. I think that all three of those claims are deeply problematic.
>
> If anything the evidence indicates that the great cognitive achievement in human evolution was cortical plasticity, which allows for rapidly adaptive changes to the environment, both across evolutionary time and [across] individual lifetimes. Because of that, we're not quite the Pleistocene relics that Evolutionary Psychology claims. [Regarding universality,] all of the evidence indicates that [behavioral] polymorphisms are much more widespread in all sexually reproducing populations than the idea of a universal human nature would require. So I think the theoretical foundations from which a lot of predictions get made, about what our mate preferences are going to be, or what the psychology of parental care is, are problematic because the theoretical foundation is mistaken.[101]

An article by David Buller and Valerie Gray Hardcastle presents a detailed critique of evolutionary psychology's concept of modularity.

[99] 'Einstein's Mental Images', pp. 283–4.

[100] *Adapting Minds: Evolutionary Psychology and the Persistent Quest for Human Nature* (Cambridge, MA and London, 2005). The review by Johan J. Bolhuis in *Science*, 309 (2005), 706 states that: 'It sets the standard for the continuing debates on evolutionary psychology'.

[101] 'Psyching Out Evolutionary Psychology', *Scientific American*, 4 July 2005.

> [E]volutionary psychologists treat environmental factors as 'triggers' that activate the development of a module in accordance with a 'developmental program' that is coded in the genes. . . . But environmental inputs and endogenous innervations do not simply 'trigger' the formation of various processing modules. Instead, during development we find a diffuse proliferation of connectivity, which later brain activity, guided by interactions with the environment, sculpts into its final form.[102]

Howard Gardner has summarised well the implications of the new approach to creativity for the study of Einstein:

> I think extraordinary people are really made. They're made in part by their ambition, in part by their times, in part by luck, and in part by where the particular domain is at a historical moment.
>
> Einstein, for example, came at exactly the right time, when all the assumptions of physics, which had survived for two centuries under Newton, were coming into question. Everybody knew it didn't quite work, but he was the guy who could see things in a new way, in part because of what I would say he had a particular blend of intelligence. He was able to think spatially about issues that people had often thought about just mathematically. If Einstein had been born 50 years earlier or 50 years later, it's quite likely he would not have been an outstanding physicist, and certainly would not have been as revolutionary as he was, being—coming into his prime at the beginning of the century.[103]

I would just add that the challenges Einstein faced were not unique. Many theoretical physicists were aware of the situation, and Henri Poincaré even said: 'There are all the evidences of a bad crisis' in physics.[104] What is unique, and in many ways still remains ineffable, is the depth and scope of Einstein's response. As the Bible says: 'For many are called but few are chosen.'[105]

[102] 'Evolutionary Psychology, Meet Developmental Neurobiology: Against Promiscuous Modularity', *Brain and Mind*, 1 (2000): 307–25, at pp. 315–16. See also chapter 4 of Buller, *Adapting Minds*, on 'Modularity', written in collaboration with Hardcastle.

[103] 'What makes a genius? Howard Gardner considers this question in his book "Extraordinary Minds"' interview on 27 Aug. 1997. Transcription available at <http://www.pbs.org/newshour/gergen/august97/gardner_8–27.html>.

[104] See Poincaré's 1904 talk to the International Congress of Art and Science, 'The Present and Future Status of the Mathematical Physics'. First published in *Bulletin des Sciences Mathématiques*, 28 (1904), 302; and then in English in *The Monist*, 15 (1905).

[105] Matthew 22:14, King James Version.