CHAPTER 2

Nobelists Gone Wild

Case Studies in the Domain Specificity of Critical Thinking

Scott O. Lilienfeld
Emory University, University of Melbourne

Candice Basterfield
University of Melbourne

Shauna M. Bowes
Emory University

Thomas H. Costello
Emory University

Introduction

Research suggests that critical thinking skills are often surprisingly domain-specific. We survey the case histories of several Nobel Prize winners in the sciences to demonstrate that even extremely bright individuals can fall prey to bizarre ideas. These findings strongly suggest that intellectual brilliance and acceptance of weird ideas are not mutually incompatible. They also highlight the domain-specificity of critical thinking and the surprising independence of general intelligence from critical thinking. A number of cognitive errors, including bias blind spot and the senses of omniscience, omnipotence, and invulnerability; personality traits such as narcissism and excessive openness; and the "guru complex" may predispose highly intelligent individuals to disastrous critical thinking errors.

Consider the following case examples:

- **Sir Isaac Newton** (1642–1727) was among the most brilliant individuals who ever lived. Along with Leibnitz, he developed the mathematics of calculus. He formulated the basic principles of gravitation and three major laws of motion, which comprise the foundation for much of modern physics. At the same time, Newton invested much of his intellectual energy into alchemy, the mystical notion that one can transform

base metals into gold and silver (White, 1999). He was also preoccupied with strange spiritual ideas, such as calculating the exact year when God ostensibly created the universe and extracting prophecies from secret Biblical codes.

- **Sir Arthur Conan Doyle** (1859–1930) was a British physician. The fictional detective Sherlock Holmes was his brainchild. Holmes in many ways epitomized critical thinking (Konnikova, 2013). In one of his short stories about Holmes, Doyle (1892) channeled the following line into his famed protagonist: "how dangerous it always is to reason from insufficient data" (p. 11). Yet Doyle often neglected to heed his own advice in this regard. He was an uncritical believer in spiritualism who fell hook, line and sinker for the Cottingley Fairies hoax (1917–1920), in which two young cousins, Elsie Wright and Frances Griffiths, faked five photographs depicting them in a garden surrounded by small fairies (Bensley, 2006; Bensley, this volume, Chapter 4). Even though many experts at the time raised serious questions regarding the photographs' authenticity, Doyle insisted in published articles and a book that they provided definitive evidence for the paranormal. (The fairies were later revealed to be amateurish cardboard cut-outs from children's books.)
- **Alfred Russel Wallace** (1823–1913), a British naturalist, was the co-discoverer of the principle of evolution by natural selection, along with Charles Darwin. Wallace is widely regarded as the founder of biogeography, and he made seminal contributions to the study of the evolution of warning coloration in animals. Nevertheless, he was also a committed believer in spiritualism and the occult (Wallace, 1874). He insisted that the Davenport Brothers, two American magicians who fooled audiences into believing that they could communicate with the dead, possessed supernatural powers. Wallace was also convinced that a supposed spirit photographer and known fraud, Frederick Hudson, had generated an image of his departed mother. In addition, he was a devotee of phrenology (the debunked notion that one can determine personality by the pattern of bumps on the skull) and a fervent opponent of vaccination (Bensley, 2006; Kottler, 1974).
- **Benjamin "Ben" Carson** (1951–) was regarded by many as the Michael Jordan of neurosurgery. He graduated from Yale University as a psychology major in 1973 and, at the age of 33, became the youngest-ever chief of pediatric neurosurgery at Johns Hopkins University (Carson, 2011). Carson has earned more than 60 honorary doctorate degrees, and in 2010, he was inducted into the Institute of Medicine (at the time of writing, he serves as Secretary of the US Department of Housing and

Urban Development). Despite his intellectual gifts, Carson holds some decidedly peculiar ideas. He has questioned the scientific support for natural selection and the Big Bang Theory, advocated the use of untested herbal supplements derived from larch tree bark to treat cancer (Orac, 2015; Prothero, 2015), and maintained, contrary to ample historical data, that the Egyptian pyramids were constructed to store grain.

The Nobel Disease

The stories of these four individuals underscore a crucial point: Remarkably intelligent people can in some instances think and behave in remarkably irrational ways (Shermer, 2003; Stanovich, 2009; Sternberg, 2008). In this chapter, we elaborate on these case examples to examine "the Nobel Disease" (Gorski, 2008; Robson, 2019): the apparent tendency of a surprising number of Nobel Prize winners in the sciences to fall prey to exceedingly dubious claims. We say "apparent," because despite claims to the contrary (e.g., Berezow, 2016), it is unknown whether Nobel Laureates are more susceptible to weird ideas than other scientists.

Specifically, we offer capsule descriptions of seven Nobel Laureates in the sciences who embraced strange ideas, and draw on research from cognitive and personality psychology, among other domains, to offer insights into their thinking failures. In addition, in Table 2.1 we present a list of other Nobelists who have also held odd ideas, using admittedly fuzzy criteria adapted from Shermer (2003), namely, assertions that are (a) logically impossible or highly implausible in the light of scientific knowledge; (b) roundly rejected by all or virtually all scientific experts; and (c) based mostly or entirely on anecdotal or uncorroborated evidence. Because we do not believe that merely entertaining the possibility that an unsupported claim might be valid is indicative of a critical thinking lapse, we focus on Nobelists who clung to one or more weird ideas (a) with considerable conviction and (b) for much of their careers.

We concede at the outset that our analysis is marked by two limitations. First, case studies are in general better suited to the context of discovery – hypothesis generation – than to the context of justification – rigorous hypothesis testing (see Reichenbach, 1938). Nevertheless, they can sometimes afford *existence proofs*: demonstrations that a given phenomenon can occur (Davison & Lazarus, 2007). In this respect, our case histories provide evidence that extremely high levels of intelligence offer scant immunity against irrationality.

Table 2.1 *Other Nobel laureates who held/hold weird ideas*

Nobel Laureates	Nobel Prize	Nobel Disease
Pierre Curie	Physics, 1903, for the discovery of radium and polonium in the investigation of radioactivity.	Curie participated in seances with purported mediums and thought that investigations into the paranormal could answer questions about magnetism (Hurwic, 1995).
John William Strutt, 3rd Baron Rayleigh	Physics, 1904, for the discovery of the gas argon.	Rayleigh was fond of parapsychology and served as the president of the Society for Psychical Research (DeYoung, 2011; Gauld, 1968).
Phillip Lenard	Physics, 1905, for his research on cathode rays.	Lenard supported Nazi racial ideology and directed "Aryan physics" during the Nazi regime (Gunderman, 2017).
Joseph Thomson	Physics, 1906, for his discovery of the electron.	Thompson had an interest in psychic phenomena and was a member of the Society for Psychical Research for 34 years (Radin, 2006).
Santiago Ramón y Cajal	Physiology or Medicine, 1906, for his work on the human and vertebrate nervous system.	Cajal conducted research on psychic phenomena, culminating in a manuscript on hypnosis, spiritualism, and metaphysics (Sala et al., 2008).
Alexis Carrel	Physiology or Medicine, 1912, for the invention of the perfusion pump.	In a book, Carrel (1935) promoted eugenics and Nazi racial theories: "The free practice of eugenics could lead not only to the development of stronger individuals, but also of strains endowed with more endurance, intelligence, and courage." (p. 302)
Charles Richet	Physiology or Medicine, 1913, for his work on anaphylaxis, a severe and potentially life-threatening allergic reaction.	Richet was interested in extrasensory perception and believed that some mediumship could be explained by the external projection of a material substance from the medium's body. He coined the term "ectoplasm" to refer to excretions from mediums during seances (Blorn, 2010). In a 1919 book, he advocated the sterilization of people with mental disabilities (Cassata, 2011; Mazliak & Tazzioli, 2009). He was an active member of the French Eugenics Society (Lewer, 2006).
Wolfgang Pauli	Physics, 1945, for his discovery of the exclusion principle (Pauli principle).	Pauli, along with Carl Jung, developed the concept of synchronicity, a mystical phenomenon whereby events labeled as coincidences supposedly reveal an acausal connection between mental and physical experiences. Pauli was convinced that events happening around the world at the same time were somehow interconnected (Donati, 2004).

Table 2.1 (*cont.*)

Nobel Laureates	Nobel Prize	Nobel Disease
Egas Moniz	Physiology or Medicine, 1949, for prefrontal lobotomy.	At a conference, Moniz learned that cutting the connections between the frontal lobes and the rest of the brain rendered chimpanzees docile. He deduced that frontal lobotomy could be used to treat mental illness in humans and actively promoted it for this purpose (Tan & Yip, 2014).
James Watson	Physiology or Medicine, 1962, for co-discovering (with Francis Crick) the double-helix structure of DNA.	Watson has repeatedly argued without qualification that black people are inherently less intelligent than white people and maintained that "stupidity" is genetic. He reiterated these positions in a 2018 documentary: "there's' a difference on the average between blacks and whites on I.Q tests. I would say the difference is, it's genetic." In his later years, Watson suggesting that fat people are less ambitious than others and that exposure to sunlight in equatorial regions increases sexual urges (Harmon, 2019).
Julian Schwinger	Physics, 1965, for his work on quantum electrodynamics.	Schwinger conducted research on cold fusion, and after a number of failed attempts to get his papers published by the American Physical Society, resigned from the group, claiming that they suppressed academic freedom (Jagdish, 2000; Schwinger, 1990).
Ivar Giaever	Physics, 1973, for his work on electron tunneling in superconductors.	Giaever has repeatedly professed skepticism of global warming. At the Lindau Nobel Laureate Meeting in 2015, he stated that "global warming is a non-problem" and called it a "new religion" (Morano, 2015).
Arthur Schawlow	Physics, 1981, for his co-invention of the laser.	Schawlow was a strong supporter of the scientifically debunked (Mostert, 2010) technique of facilitated communication (FC) for autism and other developmental disabilities. In a book chapter, drawing on their son's experiences with FC, Schawlow and his wife discussed their positive experiences with it (Schawlow & Schawlow, 1985). Schawlow was also featured in the influential documentary "The prisoners of silence" (Palfreman, 1993), which criticized the effectiveness of FC.
Richard Smalley	Chemistry, 1996, for the discovery of a third form of carbon (fullerenes).	Smalley has promoted anti-Darwinist ideas. For example, he argued that "Evolution has just been dealt its death blow . . . with my background in chemistry and physics, it is clear evolution could not have occurred" (Smalley, 2005).

Second, the Nobel Prize is hardly an infallible indicator of scientific brilliance (Fiala & Diamandis, 2018; Keating, 2018). Many exceptionally accomplished scientists, such as British astronomer Stephen Hawking and Russian chemist and periodic table developer Dimitri Mendeleev (who was nominated for the prize in 1906 but died the following year), have never won this prize. Moreover, some important domains in science or relevant to science, such as biology, psychology, anthropology, ecology, computer science, and mathematics, are not awarded the Nobel Prize, although some individuals (e.g., psychologist Daniel Kahneman, who was awarded the Nobel Prize in Economic Sciences in 2002) in these disciplines have received this prize in fields outside their primary areas of training. Finally, the Nobel Prize's overriding emphasis on individual accomplishment may be outmoded today, when interdisciplinary collaboration is increasingly required for scientific breakthroughs. These caveats notwithstanding, there is little dispute that virtually all individuals who have received prizes in the three scientific fields recognized by Nobel committees – Chemistry, Physics, and Physiology or Medicine – have made what were widely regarded at the time as landmark advances.[1]

The Domain-Specificity of Critical Thinking

The co-existence of intellectual brilliance and odd beliefs in some Nobel Laureates affords fruitful insights into the domain-specificity of critical thinking. Although critical thinking may to some extent be a generalized attribute (Facione, Facione, & Sanchez, 1994), it can vary markedly across areas of knowledge.

The extent to which critical thinking is domain-general or domain-transferable is scientifically controversial (Perkins & Salomon, 1989). Do critical thinking skills acquired within the confines of a physics education, for instance, transfer to other disciplines, such as biology (Bailin, 2002)? Much of the critical thinking literature conceptualizes such thinking as domain-general (Sá, West, & Stanovich, 1999). From this perspective, abstract rules of critical thinking are teachable and applicable to everyday problems (Nisbett et al., 1987). For example, studies suggest that teaching students about the law of large numbers (i.e., larger samples tend to yield more stable estimates) transfers to a wide variety of everyday probability

[1] In the light of (a) space considerations and (b) ongoing debates regarding the status of economics as a science (Eichner, 1983), we do not discuss Nobel winners in the Economic Sciences, although we would be remiss not to note that some writers have accused certain recipients in this field of succumbing to Nobel Disease (e.g., Berezow, 2016).

problems (Fong, Krantz, & Nisbett, 1986; Nisbett et al., 1983). One of the challenges inherent in acquiring critical thinking skills across multiple contexts is the paucity of retrieval cues to trigger the application of critical thinking skills to novel contexts (Halpern, 1998). Nevertheless, the domain-general approach posits that transfer is possible given appropriate educational strategies that (a) provide sufficient practice with applying ("bridging") critical thinking skills across domains, (b) facilitate transfer across contexts and; (c) encourage metacognition, that is, thinking about thinking (Ennis, 1987; Halpern, 1998).

In contrast, the cognitive and developmental literatures have been less sanguine about the generalized impact of critical thinking training, and instead tend to posit a domain-specific approach. This view stems from the observation that transferring domain-specific critical thinking knowledge to new domains is challenging (Perkins & Salomon, 1989; Willingham, 2008). Classic research suggests that solving logic problems is often reliant on domain-specific knowledge, because training in one version of a problem (e.g., how to destroy a stomach tumor with ray beams without damaging the surrounding tissue) frequently leads to no improvement when solving a superficially different version of the same problem (Catrambone & Holyoak, 1989; Hayes & Simon, 1977). Such studies suggest that the implementation of problem-solving skills is often highly situation-specific (Brown, Collins, & Duguid, 1989), and dependent on familiarity with the specific domain of knowledge and its context (Alexander, Kuilikowich, & Schulze, 1994; Ceci, 1993).

None of this implies that generalized critical thinking is impossible to teach, or that critical thinking cannot become generalized. For example, in some studies, teaching individuals to "consider the opposite" or "consider the alternative" may be a somewhat effective "meta-rule" that decreases confirmation bias across multiple tasks (Beaulac & Kenyon, 2018). Still, critical thinking skills acquired in one domain often fail to generalize to others, and individuals can be excellent critical thinkers in one discipline but not in others.

In this respect, acquiring critical thinking skills may be akin to acquiring athletic skills. Although there are almost surely some physical capacities, such as foot speed and upper body strength, that can assist people to excel across diverse sports, these capacities often fail to lead to generalized sports excellence. Even Michael Jordan, arguably the greatest basketball player of all time, struggled unsuccessfully to overcome mediocrity as a hitter during his brief foray into minor league baseball (Klawans, 1996).

Nobelists Gone Wild: Seven Case Studies

Bearing issues of the domain-specificity of critical thinking in mind, we now present capsule case descriptions of seven science Nobel Prize winners who held and in many cases pursued weird ideas for extended time periods (again, see Table 2.1, for other examples). We list them chronologically in the order of their Nobel Prizes.

Linus Pauling (1901–1994). In 1925, Linus Pauling earned his Ph.D. in chemistry from the California Institute of Technology. In the late 1920s, he used quantum mechanics to unravel the mysteries of chemical bonding. This work culminated in *The Nature of the Chemical Bond* (Pauling, 1960), widely considered one of the most influential chemistry books of the century (Watson, 2001). Pauling received the 1954 Nobel Prize in Chemistry "for his research into the nature of chemical bond and its application to the elucidation of the structure of complex substances" (Nobel Media AB, 2019b). Pauling also earned the 1962 Nobel Peace Prize for his advocacy on nuclear disarmament, making him the only person to be awarded two unshared Nobel Prizes, a distinction he retains to this day. In an exchange with a graduate student about how he achieved success, Pauling said that "I just have lots of ideas, and throw away the bad ones" (Oregon State University Special Collections & Archives, 1991–2000). One might contend, however, that he at times neglected to follow the second half of his recommendation.

In 1941, Pauling was diagnosed with Bright's disease, which causes chronic inflammation of the kidneys. Following his physician's advice, he adopted a low-protein salt-free diet and ingested vitamin supplements (Peitzman, 2007). Fortunately, Pauling was able to control the illness; less fortunately, he attributed his improvement to the supplements. He later claimed that 1000 milligrams of Vitamin C a day can reduce the incidence of common colds by 45 percent (Pauling, 1970). Throughout much of his life, Pauling reportedly consumed at least 12,000 milligrams of Vitamin C daily (and up to 40,000 milligrams when he felt himself getting a cold), even though the recommended daily allowance is 60 milligrams (Barrett, 2014a). Pauling further asserted that Vitamin C can cure cancer.

In the 1970s, Pauling redirected his research interests to vitamins, teaming up with psychiatrist Ewen Cameron. They treated 100 advanced cancer patients with 10,000 milligrams of Vitamin C per day. These patients' clinical course was compared with that of 1,000 patients from the same hospital who had not received Vitamin C. The authors reported that terminal cancer patients treated with megadoses of Vitamin C survived three to four times longer than control patients (Cameron & Pauling, 1976). Nevertheless, the

controls were not matched by age, stage of cancer, or performance status (DeWys, 1982). Pauling published a revision of his first book in 1976, in which he argued for even higher doses of Vitamin C (Pauling, 1976), and again in another book, in which he claimed that megadoses of Vitamin C can prolong cancer patients' lives (Cameron & Pauling, 1979).

Later research was not kind to Pauling's claims, perhaps because virtually all excess Vitamin C is excreted through the urine and hence is of little or no therapeutic value. Three double-blind trials of megadoses of Vitamin C to treat cancer undertaken by the Mayo Clinic revealed no benefits (Creagan et al., 1979; Moertel et al., 1985; Tschetter, Creagan, & O'Fallon, 1983). Pauling dismissed these negative findings and vigorously promoted high doses of Vitamin C for cancer and the common cold. Elsewhere, he argued in several articles, including one in *Science* (Pauling, 1968), that mega-doses of Vitamin C are effective for schizophrenia. Controlled studies have yielded at best mixed and mostly negative support for this hypothesis (Hoffer, 2008). In 1991, Pauling was diagnosed with prostate and rectal cancer. He underwent two surgeries but declined other standard medical treatments, opting instead for high doses of Vitamin C. Sadly, he died three years later.

William Shockley (1910–1989). William Shockley studied physics and received his Ph.D. from Massachusetts Institute of Technology in 1936. He later worked at Bell Telephone Laboratories in New Jersey, where he conducted research on semiconductors. AT&T was experiencing problems with long-distance communications and wanted to develop an amplifier using semiconductors to make the signal more reliable. Shockley, along with John Bardeen and Walter Brattain, succeeded in developing an amplifier using a transistor. In 1956, they received the Nobel Prize in Physics for the development of the transistor, widely considered one the most important inventions of the twentieth century (Martil, 2018).

Shockley later became a professor at Stanford University, where his interests eventually drifted into genetics. He argued without qualification that the Black–White IQ difference is largely or entirely genetic (see also James Watson in Table 2.1). On a television show in 1974, Shockley stated that: "My research leads me inescapably to the opinion that the major cause of the American Negro's intellectual and social deficits is hereditary and racial genetic in origin and thus not remediable to a major degree by practical improvements in environment" (Reinhold, 1973, p. 38). In another quote, Shockley even maintained that "Nature has color-coded groups of individuals so that statistically reliable predictions of their adaptability to intellectual rewarding and effective lives can easily be made and profitably used by the pragmatic man-in-the-street" (Shockley, 1972, p. 307).

Shockley proposed the idea of "retrogressive evolution," contending that Blacks were reproducing more rapidly than Whites, leading to a decline in the overall intelligence of the population. Shockley endorsed various radical "solutions" to this perceived problem, such as offering financial incentives to genetically disadvantaged people to undergo sterilization (Strauss, 2015). Shockley donated his sperm to the Repository for Germinal Choice, pejoratively termed the "Nobel Prize sperm bank," which was established by Robert Klark Graham with the intent of creating a eugenics program (Morrice, 2005).

Brian Josephson (1940–). Brian Josephson attended the University of Cambridge, where he studied physics, and earned his Ph.D. in 1964. He conducted research on quantum tunneling (a quantum phenomenon whereby particles move through a barrier that should be impossible to penetrate according to classical physics principles) while he was a Ph.D. student, showing that some materials performed as switches that could travel close to the speed of light (Josephson, 1964). Josephson's discovery earned him the 1973 Nobel Prize in Physics "for his theoretical predictions of the properties of a supercurrent through a tunnel barrier" (Nobel Media AB, 2019a).

In the late 1960s, Josephson became a follower of Maharishi Mahesh Yogi, the founder of transcendental meditation, a technique purported to induce a novel state of consciousness via the use of a mantra, a specific word repeated many times (Wallace, 1970). Josephson argued that TM "allows traumatic experiences to come back unrepressed to the mind's eye, provides a focus as an alternative to daydreaming, and the lack of a goal may lead to creative success" (*New Scientist*, 1974, p. 416). The assertion that psychological techniques permit the accurate retrieval of repressed memories is highly questionable (McNally, 2012).

In the early 1970s, Josephson launched the Mind–Matter Unification Project at Cambridge University to explore the relation between quantum mechanics and consciousness, and the links between science and Eastern mysticism. In a booklet to mark the 100th anniversary of the Nobel Prize, Josephson noted that he was working hard to keep the UK at the "forefront of research" on telepathy (a form of extrasensory perception that involves the capacity to read others' minds): "Quantum theory is now being fruitfully combined with theories of information and computation. These developments may lead to an explanation of processes still not understood within conventional science such as telepathy . . . " (McKie, 2001).

Josephson is also a vocal proponent of cold fusion, the discredited hypothesis (Epstein, 1998) that nuclear reactions can occur at room temperature. In

attempting to explain repeated unsuccessful efforts to replicate initial positive findings of cold fusion by two University of Utah researchers in the 1980s, he argued that "the fact that many who tried to reproduce the phenomenon failed should not have been considered conclusive, since phenomena in materials are sometimes difficult to reproduce" (Josephson, 2012).

In addition, Josephson has expressed strong support for "water memory," the mystical idea that water can "remember" the chemical properties of substances that have been diluted in it. Water memory is the purported mechanism underlying the debunked medical practice of homeopathy (Ernst, 2010). Josephson attended "'New Horizons in Water Science': Evidence for Homeopathy," a London conference held in 2018 (Homeopathy Research Institute, 2018).

Nikolaas Tinbergen (1907–1988). Nikolaas Tinbergen studied biology at Leiden University, where he received his Ph.D. in 1932. His seminal work focused on ethology, the study of animal behavior. In his classic book, *The Study of Instinct* (Tinbergen, 1951), he explored the influence of external and internal stimuli on the behaviors of animals and these behaviors' evolutionary functions (Hinde, 1956). In 1973, Tinbergen, Karl von Frisch, and Konrad Lorenz shared the Nobel Prize in Physiology or Medicine "for their discoveries concerning organization and elicitation of individual and social behavior patterns."

Very soon after receiving the Nobel Prize, Tinbergen turned his attention to childhood psychological disorders and applied his ethological techniques to early infantile autism, now termed autism spectrum disorder. His environmental hypotheses concerning the etiology of autism were highly speculative and inconsistent with growing evidence at the time that autism was primarily of genetic and neurological origin (Folstein & Rutter, 1977); such data have continued to mount in the interim (Tick et al., 2016).

Tinbergen's work culminated in the book *Autistic Children: New Hope for a Cure* (Tinbergen & Tinbergen, 1985), in which he and his wife recommended "holding therapy" as a cure for autism. In his Nobel address, Tinbergen (1973) had described the effects of this treatment on autism as "surprisingly rapid" (p. 119). Holding therapy is premised on the unsupported position that autism is caused by a defective attachment of child to mother. This deficit causes the child to withdraw from the world, resulting in communicative and social problems. According to Tinbergen, to cure autism, parents need to hold their children for long periods of time while attempting to establish eye contact with them, even if they resist it. Tinbergen (1973) further advocated the Alexander Technique, which manipulates posture and musculature, as a treatment for autism.

Research has provided no compelling or even suggestive evidence for any of these claims. A synthesis of the literature revealed that holding therapy is not merely empirically unsupported but also associated with serious physical harm in some cases (Mercer, 2013). Nor has any evidence emerged for the effectiveness of the Alexander Technique for autism.

Kary Mullis (1944–2019). Kary Mullis received his Ph.D., in biochemistry from the University of California, Berkeley in 1972. In 1979, he began working as a chemist for the Cetus Corporation. At the time, analyzing DNA information required large amounts of DNA. To circumvent this problem, Mullis invented polymerase chain reaction (PCR), which allows a small amount of DNA to be rapidly copied billions of times. In recognition of this landmark invention, Mullis shared the Nobel Prize in Chemistry in 1993 with Michael Smith. PCR has exerted an enormous impact on research in medicine, genetics, biotechnology, and forensics.

In his 1998 autobiography, Mullis expressed forceful disagreement with the view that acquired immunodeficiency syndrome (AIDS) is caused by the human immunodeficiency virus (HIV). He claimed that this retrovirus is barely detectable in people with AIDS, contending that this finding raises serious questions concerning its role in the illness: "Years from now, people will find our acceptance of the HIV theory of AIDS as silly as we find those who excommunicated Galileo" (Mullis, 1998, p. 180). Ironically, PCR has exerted a substantial impact on AIDS research, whereby it can detect the presence of HIV's genetic material (RNA) and provide an accurate screen of blood supply to detect early infections before antibodies to HIV have developed (Young et al., 2000). Contrary to Mullis's claims, scientists have shown conclusively that HIV causes AIDS (Blattner, Gallo, & Temin, 1988).

Mullis also questioned the evidence for human-made global warming, disputing assertions that industrial waste gases cause the earth to become hotter. On his website, he stated that "we have no good reason to think we understand climate. To make predictions about what follows from here and when, and to audaciously begin the discussion by implicating our humble species in the whole thing is worse than audacious, it's pathetic." (Mullis, n.d.) Nevertheless, virtually all climate scientists agree that the primary cause of global warming is the human expansion of the greenhouse effect (United States Global Change Research Program, 2009).

Mullis descended further into the swamp of weird ideas by voicing his belief in astrology, the scientifically discredited (Quinn, 2015) theory that the precise placement of planets at the moment of one's birth determines one's personality (Quinn, 2015). He wrote that:

> Most of them [psychologists] are under the false impression that it [astrology] is non-scientific and not a fit subject for their serious study. They are dead wrong. Whether or not the present-day practitioners of astrology are using scientific methods has no direct bearing on whether the body of knowledge they employ is true and valid. To have dismissed it without any experimental evaluation as insubstantial drivel from the masses says a lot about the fact that the present-day mental health practitioners have their heads firmly inserted in their asses and generally need more help than they provide (Mullis, 1998, p.149).

Louis J. Ignarro (1941–). Louis Ignarro attended the University of Minnesota, where he received his Ph.D. in psychopharmacology. In the 1970s, Ignarro was inspired by Murad's studies on how nitroglycerin and nitric oxide cause blood vessels to expand (Arnold et al., 1977) and started to conduct his own research. Ignarro discovered that nitric oxide is a key signaling molecule that regulates blood pressure. Ignarro's work uncovered a novel mechanism by which blood vessels dilate. The discovery has permitted the discovery of new medications to treat cardiovascular disease as well as of Viagra (sildenafil citrate), which operates via nitric oxide transmission. Ignarro, along with Robert Furchgott and Ferid Murad, received the 1998 Nobel in Physiology or Medicine for "for their discoveries concerning nitric oxide as a signaling molecule in the cardiovascular system."

A few years later, Ignarro was hired as a consultant for *Herbalife*, a widely criticized company that develops and sells empirically unsupported dietary supplements and vitamins, and later became a member of the company's Scientific Advisory Board. Ignarro first worked with Herbalife to promote a dietary supplement, Niteworks, which is a powder mix of amino acids and antioxidants that purportedly boost the body's production of nitric oxide.

In 2004, Ignarro and his colleagues conducted a study in which mice with high cholesterol levels were forced to exercise and received arginine, Vitamin C, and Vitamin E, which are all ingredients in Niteworks. They compared these mice with sedentary mice and mice that received only supplements, finding that the mice who received supplements developed fewer problems with their coronary arteries (Napoli et al., 2004). Ignarro and his colleagues published a paper in the *Proceedings of the National Academy of Sciences* touting the benefits of the ingredients in Niteworks (Napoli et al., 2004). Despite the questionable applicability of Niteworks to humans, Ignarro was quoted as saying "What's good for mice is good for humans" (Evans, 2004). Given that Ignarro was a member of the National Academy of Sciences, he was able to submit the manuscript without peer

review and did not disclose his financial interests in Herbalife. After Ignarro's ties to Herbalife were revealed, the journal issued a correction, citing his undisclosed "conflict of interest" (Barrett, 2014b). As of 2012, Ignarro had received at least fifteen million dollars from Herbalife (Schneider, 2018). Nevertheless, there is virtually no independent evidence for the effectiveness of Niteworks in humans (Barrett, 2014b).

Luc Montagnier (1932–). Luc Montagnier received his medical degree at the University of Paris in 1960. In the early 1980s, he led a team of scientists to find the cause of what was then a new and mysterious disease: AIDS. Montagnier later co-founded the World Foundation for AIDS Research and Prevention in 1993. In 2008, Montagnier and Françoise Barré-Sinoussi received the Nobel Prize in Physiology or Medicine for their discovery of HIV.

One year following his receipt of the Nobel Prize, Montagnier published a paper in *Interdisciplinary Sciences: Computational Life Sciences,* a journal he founded and edited (Montagnier et al., 2009). It took a mere two days for his paper to be accepted following submission (Hall, 2009). In this article, he maintained that diluted DNA from pathogenic bacterial and viral species can emit electromagnetic waves. Montagnier, along with Josephson, participated in the 2018 "'New Horizons in Water Science': Evidence for Homeopathy?" conference and in a 2014 documentary on homeopathy in which he claimed that "water has memory" (Leconte, Manil, & Lichtenstein, 2014). When Montagnier was probed on his views about homeopathy, he responded: "I can't say that homeopathy is right in everything. What I can say now is that the high dilutions are right. . . . even at [a dilution of] 10^{-18}, you can calculate that there is not a single molecule of DNA left. And yet we detect a signal" (Enserink, 2010).

Montagnier further claims that most neurological diseases, including Alzheimer's, Parkinson's, autism, and multiple sclerosis, arise from the electromagnetic waves emitted from viral or bacterial DNA in aqueous solutions. He contends "that products from gut bacteria end up in the plasma and cause damage to the brain" (Enserink, 2010).

In addition, Montagnier uses quantum field theory to promote the concept of "DNA teleportation," which holds that DNA can teleport between test tubes and replicate in distant aqueous solutions (Dillow, 2011). He further maintains that vaccines cause autism even though this claim has been discredited by controlled research (Taylor, Swerdfeger, & Eslick, 2014). He participated in fervent vaccine opponent Jenny McCarthy's *Autism One* conference in 2012 and appeared in Andrew

Wakefield's[2] anti-vaccination documentary "VAXXED" in 2016 (Orac, 2017; Salzberg, 2012). He also contends that AIDS, like autism, can be treated using untested natural remedies, such as dietary methods, probiotics, and antibiotics, and promoted this notion in the HIV/AIDS denialist film "House of Numbers" in 2011.

Implications for the Psychology of Critical Thinking

Bearing in mind the limitations of case studies for drawing scientific inferences (Davison & Lazarus, 2007), what insights can we glean from the weird beliefs of these Nobel Laureates, along with those in Table 2.1?

Overarching Conclusions

We would seem to be on reasonably firm ground in drawing two general conclusions. First, these cases offer compelling existence proofs that even though critical thinking may be a generalizable higher-order skill in some cases, it can also be surprisingly domain-specific. If we assume that (a) critical thinking entails the capacity to compensate for one's biases (e.g., Nickerson, 1987) and (b) these Nobelists' scientific achievements required at least some critical thinking skills in their chosen domains, these case studies strongly suggest that superb critical thinking skills in one discipline do not necessarily extend to others. This absence of transfer may be especially likely when scientists have had scant opportunity to engage in deliberate practice in these other fields (Ennis, 1989). Individuals with expertise in a domain perform better on problem-solving and critical thinking tasks specific to this domain (Chiesi, Spliich, & Voss, 1979; Nokes, Schunn, & Chi, 2010), probably because their domain-specific knowledge allows them to appraise propositions that fall within their intellectual wheelhouse better. Consistent with this perspective, data suggest that when experts operate within their realm of expertise, they tend to rely on logic, whereas when they operate outside their realm of expertise, they tend to rely on intuition (Kahneman & Frederick, 2002). In the latter case, they may neglect to apply the same standards of intellectual rigor that they do to their primary domains of knowledge. A further problem is that the intellectual skills needed for success in one field, such

[2] Wakefield was first author on a notorious paper in the premier British journal *The Lancet*, which claimed that vaccines contribute to autism (Wakefield et al., 1998). The paper has since been retracted by the journal on the grounds of its being ethically and scientifically suspect.

as physics, may often overlap minimally with those in different fields, such as psychology. For example, some subfields of psychology may require certain conceptual abilities that are largely absent from physics. Along with regression to the mean (the principle that extreme scores tend to become less extreme over time), such findings may explain why some eminent physicists, such as Donald Glaser, who won the Nobel Prize in physics for inventing the bubble chamber, failed to achieve anywhere near the same level of success when they shifted their scholarly interests to psychology (Lilienfeld & Lynn, 2016; Lykken, 1991).

Second, these case studies remind us that high levels of general (analytical; see Sternberg, 1984) intelligence afford no absolute immunity against disastrous critical thinking failures. General intelligence tends to be largely or entirely uncorrelated with most cognitive biases, such as base rate neglect, belief bias, myside bias, and confirmation bias (Stanovich & West, 2008; Stanovich, West, & Toplak, 2013); perhaps explaining why smart people often fall prey to intuitive thinking errors. Whereas scores on general intelligence measures reflect *maximal* performance – how well people *can* perform when pushed to the limit – scores on cognitive bias measures generally reflect *typical* performance – how well people *generally* perform under ordinary circumstances (see Cronbach, 1960, for a discussion of this distinction). Hence, even extremely smart people may neglect to exercise their critical thinking capacities when they are insufficiently motivated to do so, especially when they are sure they are right. One key function of critical thinking is to override intuitions that do not pass muster (Kahneman, 2011; Stanovich & West, 2008) or, in Linus Pauling's terms, to throw out bad ideas. Although highly intelligent individuals may be more capable than other individuals at subjecting ideas to critical scrutiny, they may not always be driven to do so. As a consequence, they may unknowingly allow foolish ideas to pass unchecked through their mental filters.

Data further suggest (West, Meserve, & Stanovich, 2012; Watts, 2018) that general intelligence is largely uncorrelated with *bias blind spot* (Pronin, Lin, & Ross, 2002). Bias blind spot, which is a meta-bias (a bias regarding our biases), refers to the fact that most of us are adept at identifying cognitive biases, such as confirmation bias, in other people, but not in ourselves. We are not merely blind in many cognitive domains, but blind to our blindness. Some data even point to a modest positive association between general intelligence and bias blind spot, raising the possibility that high levels of intelligence are slightly associated with the perception that one is largely immune to cognitive errors (West, Meserve, & Stanovich, 2012).

Potential Sources of Foolish Behavior

Although these findings require replication, they are broadly consistent with the observation that exceedingly smart people can sometimes believe and do exceedingly stupid things (Hyman, 2002; Shermer, 2003; Stanovich, 2009; Sternberg, 2002). Sternberg (2004) proposed an *imbalance theory of foolishness* that describes five cognitive sins that accompany unwise behavior. Many of them may account for the weird ideas of some Nobel Laureates. First, *unrealistic optimism* occurs when we believe that because we are smart, we need not worry about intellectual failure. Second, *egocentrism* arises when we become so enamored of ourselves that we disregard the impact of our views or behaviors on others. Third, the *sense of omniscience* can develop when we believe we are so intelligent that we know virtually everything. Fourth, the *sense of omnipotence* occurs when we are so impressed with our power and fame that we believe we can accomplish almost anything. Fifth, the *sense of invulnerability* emerges when we believe that we are so smart that we are largely immune to error.

Motivated Reasoning

High intelligence may contribute to weird ideas via an additional pathway. Very smart people may be especially adept at *motivated reasoning*, thinking invoked in the service of justifying a desired belief (Kunda, 1990). When we engage in motivated reasoning, we begin with a conclusion that we want to reach, and then unknowingly reason backward to persuade ourselves that it is correct. Ironically, although the process involves reasoning, the conclusions reached are often unreasonable (Kahan, 2013). Because of their formidable powers of reasoning, extremely smart people may be especially gifted at convincing themselves that their foolish beliefs are plausible. Furthermore, when confronted with evidence that contradicts their positions, they may be especially adept at parrying it away with superficially clever rhetorical ploys. In the words of Shermer (2003), "high intelligence . . . makes people skilled at defending beliefs arrived at for non-smart reasons" (p. 72).

The Role of Personality

Individual differences in personality probably play a role in critical thinking failures, perhaps especially among highly intelligent individuals. Dovetailing with Sternberg's (2004) focus on egocentrism, data suggest that narcissism is positively correlated with the magnitude of bias blind

spot (Watts, 2018), meaning that egocentric individuals tend to assume they are largely immune from cognitive errors that afflict others. Similarly, some evidence suggests that narcissism is negatively correlated with *intellectual humility* (Krumrei-Mancuso & Rouse, 2016), a propensity to be cognizant of one's biases and mental limitations. In Sternberg's (2004) terminology, narcissistic individuals may be especially susceptible to various sins that predispose to foolishness, including the senses of omniscience, omnipotence, and invulnerability.

Admittedly, the relevance of these findings to Nobel Laureates and other brilliant scientists is conjectural, as we are unaware of any systematic evidence that these individuals are more narcissistic than other scientists or members of the general population. Nevertheless, data suggest that among scientists, high levels of creativity are associated with such traits as confidence, dominance, self-esteem, and ambition (Feist, 1998). Most or all of these attributes, especially when markedly elevated, overlap with narcissism. In conjunction, they may provide the recipe for the "chutzpah" needed to generate and propose daring ideas, but they may also contribute to overweening intellectual hubris via many of Sternberg's (2004) sins.

Another individual difference variable that may contribute to critical thinking failures among highly intelligent scientists is openness to experience (openness). This trait captures the extent to which individuals are intellectually curious, imaginative, and inclined to relish novel ideas and sensations. Openness is the only broad personality trait to be positively, albeit moderately, associated with general intelligence (Ackerman & Heggestad, 1997). Scientists are higher in openness than are nonscientists, and creative scientists are even higher in openness than their less creative counterparts (Feist, 1998). Although openness correlates with many positive attributes, such as creativity (McCrae, 1987), it may be a double-edged sword. For example, extremely high levels of openness appear tied to a propensity toward peculiar and irrational thinking (Carter, Miller, & Widiger, 2018). Hence, the very levels of elevated openness that can facilitate creative thinking in scientists may also place them at risk for weird ideas, especially if they do not implement concerted cognitive precautions against them.

The Guru Complex

Finally, social reinforcement may further fuel critical thinking failures. Once scientists attain "guru" status by virtue of their outstanding scholarly achievements and prestigious academic awards, their pronouncements may come to be accepted uncritically by legions of followers (Sperber,

2010), predisposing them to the sense of invulnerability (Sternberg, 2004). This process may account in part for the Nobel Disease. It may also help to explain why some prominent public intellectuals often say and write foolish things when they venture far outside their domains of expertise (Posner, 2009). Fame and the accompanying adoration of acolytes in a circumscribed discipline can distort experts' self-perceptions, leading them to underestimate their intellectual frailties, especially in domains in which they are woefully inexperienced.

Take-Home Messages

Our analysis leaves us with four take-home messages that can help us to become more appropriately skeptical consumers of confident pronouncements by eminent scientists. These lessons bear broader implications for critical thinking successes and failures.

(1) Critical thinking may be a generalized set of skills, but it can also be surprisingly domain-specific. Merely because one is an excellent critical thinker in Domain X does not mean that one is an excellent, or even especially good, critical thinker in Domain Y.
(2) Extremely high levels of intelligence are no guarantee of good critical thinking skills, especially in domains that lie far outside the individual's expertise. Intelligence and rationality are largely independent cognitive domains.
(3) Just because a brilliant scientist, even a Nobel Laureate, advances an assertion with utmost confidence does not mean that we should accept it uncritically. Our critical thinking skills in certain domains may be superior to theirs.
(4) Few psychological attributes are unalloyed positives or negatives. Some of the same traits that foster bold thinking, such as narcissism and openness, may also foster foolish thinking.

Scott Lilienfeld: My Journey as a Critical Thinker

I was not always a critical thinker, let alone a good one. As a child and young adolescent, I was fascinated by ghosts and UFOs, and even entertained the possibility that the earth had been visited by ancient astronauts. In my high school and in my early college years, I was an uncritical devotee of some of the outré ideas of Freud and Jung. It was not until my graduate education in clinical psychology at the University of

Minnesota, when I was exposed to such clear-headed thinkers as Paul Meehl, David Lykken (my primary Ph.D. mentor), Auke Tellegen, Will Grove, and Tom Bouchard, that I came to fully appreciate the value of intellectual rigor. These and other scholars to whom I am profoundly indebted were not merely uncommonly intelligent, but they were also outstanding critical thinkers. They taught me to subject my cherished hypotheses to ruthless intellectual scrutiny, and to understand the difference between intuition and reason. They also taught me to be cautious of the affect heuristic, the tendency to use our emotional reactions to ideas as a barometer of their veracity. As I became a faculty member in clinical psychology, I came to realize belatedly that our discipline was too tolerant of sloppy thinking, and that such thinking was exerting deleterious consequences in the domains of clinical work and research. Over the past two decades, I have dedicated a hefty chunk of my career to teaching and writing about scientific thinking skills, dispelling psychological myths, and promoting evidence-based practice. Along the way, I have made some intellectual enemies, but far more intellectual and close personal friends. I also hope that in some modest way, I have encouraged psychology students to disseminate critical thinking to the next generation. It has been an enormously fulfilling voyage for me and, as Edith Piaf sang, "je ne regrette rien."

Critical Thinking about Critical Thinking Questions

(1) Although some Nobel Laureates have embraced weird ideas, most have not fallen prey to this temptation. What factors might help to explain why they have not?
(2) Would you expect the same tendencies observed by the authors to hold for Nobel Prize winners in Literature? What about Economic Sciences or Peace? Why or why not?
(3) The authors briefly mention confirmation bias as an important cognitive error. But might there be cases in which a tendency to seek out and interpret evidence consistent with one's hypotheses is advantageous in the early phases of scientific exploration? Explain.
(4) The authors mention several personality traits, such as narcissism and high openness, that may place intelligent people at risk for critical thinking failures. Might there be others?
(5) Can the domain-generality of critical thinking co-exist with a certain degree of domain-specificity? Or are these two models of critical thinking mutually exclusive? Explain.

Key Terms

Bias blind spot A pervasive tendency to identify cognitive biases in others but not in ourselves.

Domain-specificity The notion that some psychological capacities, such as critical thinking, may be well-developed in specific knowledge or skill domains, such as physics, but poorly developed in others, such as psychology.

Imbalance theory of foolishness A model proposing that unwise behavior stems from several cognitive sins (errors) reflecting excessive egocentricity, confidence, and so on.

Intellectual humility The propensity to be cognizant of one's biases and mental limitations.

Motivated reasoning Thinking undertaken in the service of justifying a preferred belief.

Nobel disease The tendency of some Nobel Laureates to embrace weird ideas.

REFERENCES

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin*, *121*, 219–245.

Alexander, P. A., Kulikowich, J. M., & Schulze, S. K. (1994). How subject-matter knowledge affects recall and interest. *American Educational Research Journal*, *31*, 313–337.

Arnold, W. P., Mittal, C. K., Katsuki, S., & Murad, F. (1977). Nitric oxide activates guanylate cyclase and increases guanosine 3′: 5′-cyclic monophosphate levels in various tissue preparations. *Proceedings of the National Academy of Sciences*, *74*, 3203–3207.

Bailin, S. (2002). Critical thinking and science education. *Science & Education*, *11*, 361–375.

Barrett, S. (2014a). The dark side of Linus Pauling's legacy. Quackwatch. Online. https://www.quackwatch.org/01QuackeryRelatedTopics/pauling.html

Barrett, S. (2014b). The dubious promotion of Herbalife's Niteworks. MLM Watch. Online. https://www.mlmwatch.org/04C/Herbalife/niteworks.html

Beaulac, G., & Kenyon, T. (2018). The scope of debiasing in the classroom. *Topoi*, *37*, 93–102.

Bensley, D. A. (2006). Why great thinkers sometimes fail to think critically. *Skeptical Inquirer*, *30*(4), 47–52.

Berezow, A. (2016, December 18). Paul Krugman now has Nobel Disease. American Council on Science and Health. Online. https://www.acsh.org/news/2016/12/18/paul-krugman-now-has-nobel-disease-10609

Blattner, W., Gallo, R. C., & Temin, H. M. (1988). HIV causes aids. *Science*, *241*, 515–516.
Blorn, J. (2010). *A dictionary of hallucinations*. New York: Springer
Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*, 32–42.
Cameron, E., & Pauling, L. (1976). Supplemental ascorbate in the supportive treatment of cancer: Prolongation of survival times in terminal human cancer. *Proceedings of the National Academy of Sciences*, *73*, 3685–3689.
Cameron, E., & Pauling, L. C. (1979). *Cancer and vitamin C: A discussion of the nature, causes, prevention, and treatment of cancer with special reference to the value of Vitamin C*. Corvallis, Oregon: Linus Pauling Institute of Science and Medicine.
Carrel, A. (1935). *Man, the unknown*. New York: Doubleday.
Carson, B. (2011). *Gifted hands: The Ben Carson story*. Grand Rapids, MI: Zondervan.
Carter, N. T., Miller, J. D., & Widiger, T. A. (2018). Extreme personalities at work and in life. *Current Directions in Psychological Science*, *27*, 429–436.
Cassata, F. (2011). *Building the new man: Eugenics, racial sciences and genetics in twentieth-century Italy*. Budapest: Central European University Press.
Catrambone, R., & Holyoak, K. J. (1989). Overcoming contextual limitations on problem-solving transfer. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 1147–1156.
Ceci, S. J. (1993). Contextual trends in intellectual development. *Developmental Review*, *13*, 403–435.
Chiesi, H. L., Spliich, G. J., & Voss, J. F. (1979). Acquisition of domain-related information in relation to high and low domain knowledge. *Journal of Verbal Learning and Verbal Behaviour*, *18*, 257–273.
Creagan, E. T., Moertel, C. G., O'Fallon, J. R., Schutt, A. J., O'Connell, M. J., Rubin, J., & Frytak, S. (1979). Failure of high-dose vitamin C (ascorbic acid) therapy to benefit patients with advanced cancer: a controlled trial. *New England Journal of Medicine*, *301*, 687–690.
Cronbach, L. J. (1960). *Essentials of psychological testing* (2nd ed.). New York: Harper & Row.
Davison, G. C., & Lazarus, A. A. (2007). Clinical case studies are important in the science and practice of psychotherapy. In S. O. Lilienfeld & W. T. O'Donohue (Eds.), *The great ideas of clinical science* (pp. 149–162). New York: Routledge.
DeWys, W. D. (1982). How to evaluate a new treatment for cancer. *Your Patient and Cancer*, *2*, 31–36.
DeYoung, Ursula. (2011). *A vision of modern science: John Tyndall and the role of the scientist in Victorian culture*. New York: Palgrave Macmillan.
Dillow, C. (2011). Can our DNA electromagnetically 'teleport' itself? One researcher thinks so. Popular Science. Online. https://www.popsci.com/science/article/2011-01/can-our-dna-electromagnetically-teleport-itself-one-researcher-thinks-so
Donati, M. (2004). Beyond synchronicity: the worldview of Carl Gustav Jung and Wolfgang Pauli. *Journal of Analytical Psychology*, *49*, 707–728.

Doyle, A.C. (1892). *The Adventures of Sherlock Holmes*. United Kingdom: George Newnes.

Eichner, A. S. (1983). Why economics is not yet a science. *Journal of Economic Issues*, *17*, 507–520.

Ennis, R. H. (1989). Critical thinking and subject specificity: Clarification and needed research. *Educational Researcher*, *18*, 4–10.

Enserink, M. (2010). French nobelist escapes "intellectual terror" to pursue radical ideas in China. *Science*, *330*, 1732–1733.

Epstein, M. S. (1998). Using bad science to teach good chemistry. *Journal of Chemical Education*, *75*, 1399–1404.

Ernst, E. (2010). Homeopathy: What does the "best" evidence tell us. *Medical Journal of Australia*, *192*, 458–460.

Evans, D. (2004). Nobel prize winner didn't disclose his Herbalife contract. Cult Education Institute. Online. https://culteducation.com/group/969-herbalife/9601-nobel-prize-winIidnt-disclose-his-herbalife-contract.html

Facione, N. C., Facione, P. A., & Sanchez, C. A. (1994). Critical thinking disposition as a measure of competent clinical judgment: The development of the California Critical Thinking Disposition Inventory. *Journal of Nursing Education*, *33*, 345–350.

Farber, C. (1994). Interview Kary Mullis. Virusmyth. Online. http://www.virusmyth.com/aids/hiv/cfmullis.htm

Feist, G. J. (1998). A meta-analysis of personality in scientific and artistic creativity. *Personality and Social Psychology Review*, *2*, 290–309.

Fiala, C., & Diamandis, E. P. (2018). Is it time to abandon the Nobel Prize? *Clinical Chemistry and Laboratory Medicine*, *56*, 1196–1197.

Folstein, S., & Rutter, M. (1977). Genetic influences and infantile autism. *Nature*, *265*, 726–728.

Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The effects of statistical training on thinking about everyday problems. *Cognitive Psychology*, *18*, 253–292.

Gauld, A. (1968). *The founders of psychical research*. New York: Schocken Books.

George, A. (2006, December 9). Lone voices special: Take nobody's word for it. *New Scientist*. https://www.newscientist.com/article/mg19225812-200-lone-voices-special-take-nobodys-word-for-it

Gorski, D. (2008, August 18). High dose Vitamin C and cancer: Has Linus Pauling been vindicated? Science-Based Medicine. Online. https://sciencebasedmedicine.org/high-dose-vitamin-c-and-cancer-has-linus-pauling-been-vindicated

Gunderman, R. (2017, March 3). When science gets ugly – the story of Philipp Lenard and Albert Einstein. *National Geographic*. https://www.nationalgeographic.com.au/science/when-science-gets-ugly.aspx

Hall, H. (2009, October 20). The Montagnier "Homeopathy" Study. Science-Based Medicine. Online. https://sciencebasedmedicine.org/the-montagnier-homeopathy-study

Halpern, D. F. (1998). Teaching critical thinking for transfer across domains: Disposition, skills, structure training, and metacognitive monitoring. *American Psychologist*, *53*(4), 449–455. DOI:10.1037/0003-066x.53.4.449

Harmon, A. (2019). James Watson had a chance to salvage his reputation on race. He made things worse. *New York Times*. https://www.nytimes.com/2019/01/01/science/watson-dna-genetics-race.html

Hayes, J. R., & Simon, H. A. (1977). Psychological differences among problem isomorphs. In G. Potts (Ed.), *Indiana Cognitive Symposium*. Potomac, MD: Erlbaum.

Hinde, R. A. (1956). Ethological models and the concept of 'drive'. *The British Journal for the Philosophy of Science*, *6*, 321–331.

Hoffer, L. J. (2008). Vitamin therapy in schizophrenia. *Israel Journal of Psychiatry and Related Sciences*, *45*, 3–10.

Homeopathy Research Institute. (2018). 'New Horizons in Water Science': Evidence for Homeopathy? Homeopathy Research Institute. Online. https://www.hri-research.org/2018/08/new-horizons-in-water-science-evidence-for-homeopathy

Hurwic, A. (1995). *Pierre Curie*. Paris: Flammarion.

Hyman, R. (2002). Why and when are smart people stupid. In R. J. Sternberg (Ed.), *Why smart people can be so stupid* (pp. 1–23). New Haven, CT: Yale University Press.

Jagdish, M. (2000). *Climbing the mountain: The scientific biography of Julian Schwinger*. New York: Oxford University Press.

Jepson, C., Krantz, D. H., & Nisbett, R. E. (1983). Inductive reasoning: Competence or skill? *Behavioral and Brain Sciences*, *6*, 494–501.

Josephson, B. D. (1964). Non-linear conduction in superconductors. Doctoral dissertation, University of Cambridge.

Josephson, B. D. (1997, November 1). Letters: Molecule memories. *New Scientist*. https://www.newscientist.com/letter/mg15621067-000-letters-molecule-memories

Josephson, B. D. (2012, August 31). Martin Fleichmann obituary. *The Guardian*. https://www.theguardian.com/science/2012/aug/31/martin-fleischmann

Kahan, D. (2013). Ideology, motivated reasoning, and cognitive reflection. *Judgment and Decision-Making*, *8*, 407–424.

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich., D. W. Griffin., & D. Kahneman, (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 49–81). Cambridge: Cambridge University Press.

Keating, B. (2018). *Losing the Nobel Prize: A story of cosmology, ambition, and the perils of science's highest honor*. New York: Norton.

Klawans, H. L. (1996). *Why Michael couldn't hit: And other tales of the neurology of sports*. Basingstoke: Macmillan.

Konnikova, M. (2013). *Mastermind: How to think like Sherlock Holmes*. New York: Penguin.

Kottler, M. J. (1974). Alfred Russel Wallace, the origin of man, and spiritualism. *Isis*, *65*, 145–192.

Krumrei-Mancuso, E. J., & Rouse, S. V. (2016). The development and validation of the comprehensive intellectual humility scale. *Journal of Personality Assessment*, *98*, 209–221.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, *108*, 480–498.

Leconte, D., Manil, C., & Lichtenstein, L. (2014). Water memory. Online video clip. https://www.youtube.com/watch?v=R8VyUsVOico

Leonhardt, D. (2008, April 6). Holding on. *New York Times.* https://www.nytimes.com/2008/04/06/realestate/keymagazine/406Lede-t.html

Lewer, N. (2006). Charles Richet: Medical scientist, innovator, peace thinker and savant. *Medicine, Conflict and Survival*, *22*, 145–158.

Lewis, A. (2009). Why I am nominating Luc Montagnier for an IgNobel Prize. The Quackometer. Online. http://www.quackometer.net/blog/2009/10/why-i-am-nominating-luc-montagnier-for.html

Lilienfeld, S. O., & Lynn, S. J. (2016). You'll never guess who wrote that: 78 surprising authors of psychological publications. *Perspectives on Psychological Science*, *11*, 419–441.

Lykken, D. T. (1991). What's wrong with psychology anyway. In D. Cicchett & W. M. Grove (Eds.), *Thinking clearly about psychology* (pp. 3–39). Minneapolis, MN: University of Minnesota Press.

Markoff, J. (2008, January 13). The views of innovation colliding in Washington. *New York Times*. https://www.nytimes.com/2008/01/13/business/13stream.html

Martil, I. (2018, April 9). William Shockley the invention of the transistor. Open Mind. Online. https://www.bbvaopenmind.com/en/william-shockley-and-the-invention-of-the-transistor

Mazliak, L., & Tazzioli, R. (2009). *Mathematicians at war: Volterra and his French colleagues in World War I*. Dordrecht: Springer Science & Business Media.

McKie, R. (2001, September 30). Royal Mail's Nobel guru in telepathy row. *The Observer.* https://www.theguardian.com/uk/2001/sep/30/robinmckie.theobserver

McNally, R. J. (2012). Searching for repressed memory. In *True and false recovered memories* (pp. 121–147). New York: Springer.

McCrae, R. R. (1987). Creativity, divergent thinking, and openness to experience. *Journal of Personality and Social Psychology*, *52*, 825–847.

Mercer, J. (2013). Holding therapy: A harmful mental health intervention. *Focus on Alternative and Complementary Therapies*, *18*, 70–76.

Moertel, C. G., Fleming, T. R., Creagan, E. T., Rubin, J., O'Connell, M. J., & Ames, M. M. (1985). High-dose vitamin C versus placebo in the treatment of patients with advanced cancer who have had no prior chemotherapy: A randomized double-blind comparison. *New England Journal of Medicine*, *312*, 137–141.

Moffitt, M. (2018, August 22). How a racist genius created Silicon Valley by being a terrible boss. SFGATE. Online. https://www.sfgate.com/technology/article/Silicon-Valley-Shockley-racist-semiconductor-lab-13164228.php

Montagnier, L., Aissa, J., Ferris, S., Montagnier, J. L., & Lavalléee, C. (2009). Electromagnetic signals are produced by aqueous nanostructures derived from bacterial DNA sequences. *Interdisciplinary Sciences: Computational Life Sciences*, *1*, 81–90.

Montagnier, L., Aissa, J., Del Giudice, E., Lavallee, C., Tedeschi, A., & Vitiello, G. (2011). DNA waves and water. *Journal of Physics: Conference Series*, *306*, 1–10.

Montagnier, L., Del Giudice, E., Aïssa, J., Lavallee, C., Motschwiller, S., Capolupo, A., Polcari, A., Romano, P., Tedeschi, A., & Vitiello, G. (2015). Transduction of DNA information through water and electromagnetic waves. *Electromagnetic Biology and Medicine*, *34*(2), 106–112. DOI:10.3109/15368378. 2015.1036072

Morano, M. (2015). Noble prize-winning scientist who endorsed Obama now says prez. is 'ridiculous' & 'dead wrong' on 'global warming'. Climate Depot. Online. https://tinyurl.com/y3t5lncc

Morrice, P. (2005). 'The genius factory': Test-tube superbabies. *New York Times*. https://www.nytimes.com/2005/07/03/books/review/the-genius-factory-testtube-superbabies.html

Mostert, M. P. (2010). Facilitated communication and its legitimacy – Twenty-first century developments. *Exceptionality*, *18*, 31–41.

Mullis, K. (n.d.). AIDS and global warming. Online. https://www.karymullis.com/pdf/On_AIDS_and_Global_Warming.pdf

Mullis, K. (1998). *Dancing naked in the mind field*. New York: Vintage Books.

Mullis, K. (2007). Biography. Kary Mullis. Online. http://www.karymullis.com/pdf/biography.pdf

Napoli, C., Williams-Ignarro, S., De Nigris, F., Lerman, L. O., Rossi, L., Guarino, C., Mansueto, G., Di Tuoro, F., Pignalosa, O., De Rosa, G., Sica, V., & Ignarro, L. J. (2004). Long-term combined beneficial effects of physical training and metabolic treatment on atherosclerosis in hypercholesterolemic mice. *Proceedings of the National Academy of Sciences*, *101*, 8797–8802. DOI:10.1073/pnas.0402734101

Nattrass, N. (2007). AIDS denialism vs. science. *Skeptical Inquirer*, *31*(5), 31–37.

New Scientist. (1974, May 16). Josephson on transcendental meditation. *New Scientist*, *62*, 416.

Nisbett, R. E., Fong, G. T., Lehman, D. R., & Cheng, P. W. (1987). Teaching reasoning. *Science*, *238*, 625–631.

Nisbett, R. E., Krantz, D. H., Jepson, C., & Kunda, Z. (1983). The use of statistical heuristics in everyday inductive reasoning. *Psychological Review*, *90*, 339–363.

Nobel Media AB (2019a). Brian D. Josephson Facts. The Nobel Prize. Online. https://www.nobelprize.org/prizes/physics/1973/josephson/facts

Nobel Media AB (2019b). Linus Pauling Biographical. The Nobel Prize. Online. https://www.nobelprize.org/prizes/chemistry/1954/pauling/biographical

Nobel Media AB (2019c). Louis J. Ignarro Facts. The Nobel Prize. Online. https://www.nobelprize.org/prizes/medicine/1998/ignarro/facts

Nokes, T. J., Schunn, C. D., & Chi, M. (2010). Problem solving and human expertise. In P. Peterson., E. Baker., & B. McGraw (Eds.), *International Encyclopedia of Education* (pp. 265–272). Oxford: Elsevier.

Orac (2015, November 6). Ben Carson: A case study on why intelligent people are often not skeptics. Respectful Insolence. Online. https://respectfulinsolence.com/2015/11/06/ben-carson-why-intelligent-people-are-not-necessarily-skeptics

Orac (2017, November 28). The Nobel Disease strikes again: Luc Montagnier goes full antivax, with a little help from Henri Joyeux. Respectful Insolence. Online.

https://respectfulinsolence.com/2017/11/28/the-nobel-disease-strikes-again-luc-montagnier-goes-full-antivax-with-a-little-help-from-henri-joyeux
Oregon State University Special Collections & Archives (1991–2000). Ava Helen and Linus Pauling papers, 1873–2013. Online. https://tinyurl.com/yy4l2rv3
Palfreman, J. (1993). The prisoners of silence. Frontline. Television documentary series. Boston, MA: WGBH.
Parapsychological Association (2011, February 11). What is parapsychology? Parapsychological Association. Online. https://parapsych.org/articles/36/76/what_is_parapsychology.aspx
Perkins, D. N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational researcher*, *18*, 16–25.
Pauling, L. (1960). *The Nature of the Chemical Bond*. Ithaca, NY: Cornell University Press.
Pauling, L. (1968). Orthomolecular psychiatry. *Science*, *160*, 265–271.
Pauling, L. (1970). *Vitamin C, the common cold* (1st ed.). New York: W.H. Freeman.
Pauling, L. (1976). *Vitamin C, the common cold, and the flu* (2nd ed.). New York: W.H. Freeman.
Peitzman, S. J. (2007). *Dropsy, dialysis, transplant: A short history of failing kidneys*. Baltimore, MD: Johns Hopkins University Press.
Posner, R. A. (2009). *Public intellectuals*. Cambridge, MA: Harvard University Press.
Pronin, E., Lin, D. Y., & Ross, L. (2002). The bias blind spot: Perceptions of bias in self versus others. *Personality and Social Psychology Bulletin*, *28*, 369–381.
Prothero, D. (2015). Brain surgeon – or brain addled? *Skeptic*, *20*(4), 43–46.
Quinn, V. S. (2015). Using astrology to confront and discuss pseudoscience in the classroom. *The American Biology Teacher*, *77*, 542–548.
Radin, D. (2006). *Entangled minds*. New York: Paraview Pocket Books.
Reichenbach, H. (1938). *Experience and prediction: An analysis of the foundations and the structure of knowledge*. Chicago: University of Chicago Press.
Reinhold, R. (1973, December 5). Shockley debates Montagu as Innis angrily pulls out. *New York Times*. https://www.nytimes.com/1973/12/05/archives/shockley-debates-montagu-as-innis-angrily-pulls-out-tests-called.html
Robson, D. (2019). *The intelligence trap: Why smart people make dumb mistakes*. New York: Norton.
Sá, W. C., West, R. F., & Stanovich, K. E. (1999). The domain specificity and generality of belief bias: Searching for a generalizable critical thinking skill. *Journal of Educational Psychology*, *93*, 497–510.
Sala, J., Cardeña, E., Holgado, M. C., Anez, C., Perez, P., Periñán, R., & Capafons, A. (2008). The contributions of Ramón y Cajal and other Spanish authors to hypnosis. *International Journal of Clinical and Experimental Hypnosis*, *56*, 361–372.
Salzberg, S. (2012, May 27). Nobel laureate joins anti-vaccination crowd at Autism One. *Forbes*. https://www.forbes.com/sites/stevensalzberg/2012/05/27/nobel-laureate-joins-anti-vaccination-crowd-at-autism-one/#63ab0f595c53

Schawlow, A. T., & Schawlow, A. L. (1985). The endless search for help. In M. F. Brady & P. Gunther (Eds.), *Integrating moderately and severely handicapped learners: Strategies that work* (pp. 5–15). Springfield, IL: Charles Thomas.
Schneider, L. (2018). Fake data and real pomegranate juice in Nobelist Lois Ignarro's Papers. For Better Science. Online. https://forbetterscience.com/2018/08/27/fake-data-and-real-pomegranate-juice-in-nobelist-lois-ignarros-papers
Schwinger, J. (1990). Cold fusion: A hypothesis. *Zeitschrift für Naturforschung A*, *45*, 756–756.
Shermer, M. (2003). Why smart people believe weird things. *Skeptic*, *10*(2), 62–73.
Shockley, W. (1972). Dysgenics, geneticity, raceology: A challenge to the intellectual responsibility of educators. *The Phi Delta Kappan*, *53*, 297–307.
Smalley, R. (2005, October 29). Remarks by Richard Smalley at 2005 alumni banquet. Hope College. Online. https://hope.edu/news/2005/10/29/remarks-by-richard-smalley-at-alumni-banquet.html
Smalley, R. (2005). Creation scientists applaud PA judge's ruling against intelligent design. Free Republic. Online. http://www.freerepublic.com/focus/religion/1546528/posts
Sperber, D. (2010). The guru effect. *Review of Philosophy and Psychology*, *1*, 583–592.
Stanovich, K. E. (2009). *What intelligence tests miss: The psychology of rational thought*. New Haven, CT: Yale University Press.
Stanovich, K. E., & West, R. F. (2008). On the relative independence of thinking biases and cognitive ability. *Journal of Personality and Social Psychology*, *94*, 672.
Stanovich, K. E., West, R. F., & Toplak, M. E. (2013). Myside bias, rational thinking, and intelligence. *Current Directions in Psychological Science*, *22*, 259–264.
Sternberg, R. J. (1984). Toward a triarchic theory of human intelligence. *Behavioral and Brain Sciences*, *7*, 269–287.
Sternberg, R. J. (2002). Smart people are not stupid, but they cure can be foolish: The imbalance theory of foolishness. In R. J. Sternberg (Ed.), *Why smart people can be so stupid* (pp. 232–241). New Haven, CT: Yale University Press.
Sternberg, R. J. (2004). Why smart people can be so foolish. *European Psychologist*, *9*, 145–150.
Sternberg, R. J. (Ed.). (2008). *Why smart people can be so stupid*. New Haven, CT: Yale University Press.
Strauss, M. (2015, October 16). Nobel Laureates who were not always noble. *National Geographic*. https://news.nationalgeographic.com/2015/10/151005-nobel-laureates-forget-racist-sexist-science
Tan, S. Y., & Yip, A. (2014). António Egas Moniz (1874–1955): Lobotomy pioneer and Nobel Laureate. *Singapore Medical Journal*, *55*, 175–176.
Taylor, L. E., Swerdfeger, A. L., & Eslick, G. D. (2014). Vaccines are not associated with autism: An evidence-based meta-analysis of case-control and cohort studies. *Vaccine*, *32*, 3623–3629.

Tick, B., Bolton, P., Happé, F., Rutter, M., & Rijsdijk, F. (2016). Heritability of autism spectrum disorders: A meta-analysis of twin studies. *Journal of Child Psychology and Psychiatry*, *57*, 585–595.

Tinbergen, N. (1951). *The study of instinct*. Oxford: Clarendon Press.

Tinbergen, N. (1973, December 12). Ethology and stress diseases. Nobel Lecture, pp. 113–130. The Nobel Prize. Online. https://www.nobelprize.org/uploads/2018/06/tinbergen-lecture.pdf

Tinbergen, N., & Tinbergen, E. A. (1985). *Autistic children: New hope for a cure*. London: George Allen & Unwin.

Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschrift für Tierpsychologie*, *20*(4), 410–433.

Tschetter L., Creagan E., & O'Fallon, J. (1983). A community-based study of vitamin C (ascorbic acid) in patients with advanced cancer. *Proceedings of the American Society of Clinical Oncology*, *2*, 92.

United States Global Change Research Program (2009). Global Climate Change Impacts in the United States: 2009 Report. U.S. Global Change Research Program. Online. https://nca2009.globalchange.gov/index.html

Wakefield, A. J., Murch, S. H., Anthony, A., Linnell, J., Casson, D. M., Malik, M., Berelowitz, M., Dhillon, A. P., Thomson, M. A., Harvey, P., Valentine, A., Davies, S. E., & Walker-Smith, J. A. (1998). RETRACTED: Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. *The Lancet*, *351*(9103), 637–641. DOI:10.1016/S0140-6736(97)11096-0

Wallace, A. R. (1874). *A defence of modern spiritualism*. Boston, MA: Colby and Rich.

Wallace, R. K. (1970). Physiological effects of transcendental meditation. *Science*, *167*, 1751–1754.

Watson, J. D. (2001). *A passion for DNA: Genes, genomes, and society*. Oxford: Oxford University Press.

Watts, A. L. (2018). Confident but clueless? The nature and boundaries of the link between personality disorder features and self-enhancement. Doctoral dissertation, Emory University.

West, R. F., Meserve, R. J., & Stanovich, K. E. (2012). Cognitive sophistication does not attenuate the bias blind spot. *Journal of Personality and Social Psychology*, *103*, 506–519.

White, M. (1999). *Isaac Newton: The last sorcerer*. New York: Basic Books.

Willingham, D. T. (2008). Critical thinking: Why is it so hard to teach? *Arts Education Policy Review*, *109*, 21–32.

Young, N. L., Shaffer, N., Chaowanachan, T., Chotpitayasunondh, T., Vanparapar, N., Mock, P. A., Waranawat, N., Chokephaibulkit, K., Chuachoowong, R., Wasinrapee, P., & Mastro, T. D. (2000). Early diagnosis of HIV-1-infected infants in Thailand using RNA and DNA PCR assays sensitive to non-B subtypes. *Journal of Acquired Immune Deficiency Syndromes*, *24*, 401–407.